UNIVERSITY OF BRISTOL.

THE ANNUAL REPORT

OF THE

Agricultural and Horticultural Research Station

(THE NATIONAL FRUIT AND CIDER INSTITUTE)

LONG ASHTON, BRISTOL,

1936.

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In Memoriam.

ERNEST PONTING WEST.

Towards the final stages of completion of the present Annual Report the Department of Agriculture and Horticulture has sustained a very heavy loss in the death of Ernest Ponting West. For some months previously he had been obviously unwell, but had struggled to carry on his normal duties and deferred placing himself unreservedly under his doctor's orders. At the end of April, 1937, however, it became necessary to consult a specialist, who advised an immediate operation. This was performed and three days later he passed away.

His position in the Department was unique and not likely to be paralleled. His influence both within it and among those outside having contact with it was far beyond that normally associated with a post such as he held ; it was a genuine tribute to his personality and inspiring efforts to promote the success of the Department. In particular his pride in "The Institute"—to give the Long Ashton Research Station the name most often used in the West Country—was evident to all who knew him well and his attachment to it had justifiably a touch of a possessive character. Throughout its whole history he had been intimately associated with the inner steps of its development, stage by stage, and in many respects had played no small part in shaping its destiny.

It could fairly be claimed for him that he participated in its birth. During the earlier months of 1903 the Provisional Committee in charge of the drafting of the scheme for the establishment of a National Fruit and Cider Institute was negotiating for a site at Long Ashton with the late Dr. H. B. Napier—agent to the Ashton Court Estate, and in due course the Chairman of the Governing Body and the Managing Committee of the Institute, and its Treasurer from the time of its establishment until his death. West at that time was his personal secretary and in that capacity was fully informed of the various stages in the evolution of the scheme and of its coming into being. In October, 1903, possession of the original holding of land and buildings at the present site was obtained and the Institute began its work. From that date until his death West was directly in touch with all the major features of its development and, in many directions, with much of the detail.

He and I first met in December of that year at the time of my initial visit to the newly established Institute, which resulted in my appointment as Assistant Director (Resident). Within a year or two of that first meeting, he began to act as my personal secretary in overtime hours and assisted in dealing with the rapidly growing correspondence of the young institution, an arrangement maintained until the Institute became formally associated with the recently established University of Bristol in 1912. This union coincided with the first material expansion of the Institute, which was made possible by substantial grants from the newly created Development Fund. West was then appointed its full-time Manager-Secretary, a title reversed a few years later to Secretary-Manager.

As these two titles imply, his duties were of a very composite character, since the resources of the Station in those days did not permit nor call for more than a single appointment in that direction. The subsequent considerable growth of the Station, the establishment of the Berkeley Square Agricultural Advisory Section, and the concurrent addition of the Campden Research Station brought increasing and overwhelming additions to the work associated with his post. The difficulties thus arising were solved from time to time by the appointment of assistant staff in his office ; but he retained to the end the responsibility for his manifold original duties.

As the Department grew, he, too, grew in technical knowledge and other ways, and continued to keep himself fitted for the varied calls of an ever-expanding position. For example, on many matters relating to the subject of cider he became qualified in due course to speak with some degree of authority and developed into a sound judge of cider. The general recognition of his ability in that direction was shown by the fact that he acted in that capacity from time to time in the Cider Competitions at all the leading agricultural and other shows.

Following the death of Mr. W. J. Grant, the first Honorary Secretary of the National Fruit and Cider Institute, he was appointed to that post, and he also represented that body on the National Association of Cidermakers. The close contacts with the cider industry resulting from these positions enabled him to gain to a marked degree the goodwill and confidence of those engaged in that industry.

When Fenswood Farm was acquired for the expansion of the Long Ashton Research Station, the opportunity arrived for him to demonstrate practically that to his many other achievements could be added that of being a successful farmer. Under difficult and unusual conditions, and at a time when British agriculture was passing through a period of depression, he assumed the responsibility of the management of such parts of the farm as were not required for the experimental work on fruit culture and succeeded year after year in showing a balance on the right side.

His work in these and other directions brought him into touch with an exceptionally wide circle of agriculturists, horticulturists, and others interested in the work of the Department or having business relations with it. The many expressions of sympathy received from them when the news of his death became known were almost invariably accompanied by some reference to its great loss in terms which indicated a general recognition of the considerable share taken by him in its development to its present position. The full extent of that share can only be realised by those responsible for the control of the Department and by his older colleagues on the staff. They will remember him as one who never spared himself on its behalf nor hesitated to subordinate his own interests to the calls of his duties. To those of his colleagues who can speak from many years of close association with him on the administrative side of the Department he will remain a fine example of willing service and devoted loyalty, which won for him both their respect and affection.

B. T. P. Barker.

In Memoriam.

ROBERT NEVILLE GRENVILLE.

The death of Robert Neville Grenville, Esq., J.P., of Butleigh Court, Somerset, in August, 1936, calls for notice in the Annual Report of this Station in view of the prominent part taken by him in the establishment of the National Fruit and Cider Institute, from which the Station in its present form has arisen. He was an original member of the Governing Body of the Institute, and one of the group of members of the Council of the Bath and West Society which at the end of last century and in the first years of the present one was responsible for the scheme for experiments and research in cider-making now continuing in more permanent shape at Long Ashton.

Neville Grenville's share in this was in many respects the predominant one. The Journals of the Bath and West Society during that period have recorded how it was through his initiative that the Society began its experiments on cider, which have done so much towards raising the standard of the making of that beverage under farm conditions, and reviving general interest in the beverage, with the consequent increase in the value of the farm product and of the farm orchards from which the supplies of raw material are drawn. He placed his own orchards and cider house at the disposal of this work and equipped a temporary laboratory at Butleigh Court adjacent to the cider house for the use of those placed in charge of the investigations. The results of these may properly be regarded as furnishing the foundations of modern methods of cider-making under farm as distinct from factory conditions. The factories, too, have not failed to profit by this work under suitable modifications. In course of time it became evident that a permanent centre for this work, to take the place of the seasonal and intermittent studies at Butleigh, was necessary ; and Long Ashton was decided upon as the location of the new venture. The establishment of the National Fruit and Cider Institute in this way was thus the direct outcome of the work at Butleigh ; and although the investigations on cider ceased at the latter centre, Neville Grenville himself remained in touch with the subject in his capacity as one of the Governors and as a member of the Managing Committee of the Institute. He generously gave the staff of the young institution the benefit of his experience and advice and, until increasing age enforced a curtailment of his outside interests, he continued to maintain a close personal touch with the proceedings of the Station.

His last visit to Long Ashton will remain in the memory of those present, particularly by reason of the thoroughly characteristic and delightful speech which he then made. The occasion was the formal opening of a new extension of the laboratory at the Station in 1930 by Lord Moyne, at that time the Rt. Hon. Walter Guinness, M.P., and Minister of Agriculture and Fisheries. Speaking with his old vigour and point, he impressed a younger generation with his forceful personality and made it possible for them to realise what a powerful advocate the cider industry had possessed in the critical years at the beginning of the present century, when it was striving to recover from the stagnation into which it had drifted after the boom period of a hundred years earlier.

In the laboratory at Long Ashton there now is placed a tablet presented by him to the Institute a few months before his death. It records the pioneer work on cider at Butleigh and its transfer to Long Ashton, and was included by his special request in the exhibit contributed by the Institute to the Royal Agricultural Society's Show held in Ashton Park in July, 1936.

With his passing the Institute has lost a valuable friend and supporter, and the cider industry one to whom it owes a great debt of gratitude for his enthusiastic and disinterested efforts for its betterment.

B. T. P. BARKER.

INTRODUCTION.

By B. T. P. BARKER, M.A., Director.

The Department of Agriculture and Horticulture has undergone no changes of major importance during the year 1936. So far as its activities at the Campden Research Station have been concerned, little material alteration has resulted from the transfer of responsibility for the Treasury grant from the Ministry of Agriculture and Fisheries to the Department of Scientific and Industrial Research in 1935. Through the Food Investigation Board of the latter the contacts with other institutions associated with the Board on collateral lines of work have become closer and still more co-ordination may be expected in due course. The long absence through illness of Mr. W. B. Adam, the senior member of the staff of the Station under Mr. F. Hirst, the Director, has thrown increased work upon the latter ; but in spite of the consequent difficulties investigations of value to the canning industry of this country have progressed materially and the advisory section has again shown an increase in the calls made upon it. The appreciation of the canning industry has been reflected in the larger subscriptions received from that source. A more detailed account of the year's work appears in the Annual Report of the Campden Station.

At Bristol the Berkeley Square Agricultural Advisory Centre has more than maintained its position. Its relations with the counties of the Bristol Province continue on a very satisfactory basis. One noteworthy feature has been the expansion of its services to the counties in directions such as certain sides of the dairy bacteriological and poultry pathological work, which, strictly, lie somewhat outside the scope of the official Advisory Scheme of the Ministry and represent developments on the initiative of the University. Through these the direct links between the Advisory Centre and the counties have been strengthened and the farmers of the area have benefitted in the wider service at their disposal.

A similar report of encouraging progress in general can be given for the Long Ashton Research Station, the senior centre of the Department. In its case, however, financial problems are unfortunately restricting the rate of development. The returns from sales of produce, which form a very substantial proportion of the whole income of the Station and constitute one of the most important limiting factors on its activities, have not expanded to keep pace with the constantly increasing expenditure inevitably involved by the growth of the work ; and for the past two years they have suffered seriously from causes beyond the Station's control. The aftermath of the heavy loss due to the destruction of the fruit crops by the abnormal May frosts of 1935 has had to be faced and, coincident with that, the revenue from sales of cider has diminished in consequence of a general lowering by the industry as a whole of the net price of the beverage in the wholesale market and a slackening in demand, which has followed the reduction of the beer duty. These setbacks—temporary in part though they have been, but probably not entirely—have enforced economies and consequent restriction of development at a time when it had been hoped to show considerable headway on the resumption of the normal rate of Treasury, and county grants which had been reduced during the years following the country's financial crisis of 1931. Notwithstanding these adverse circumstances the main investigations which the Station had in hand have been maintained and a useful year's work can be recorded.

THE BERKELEY SQUARE ADVISORY CENTRE.

Staff.

Staff changes at this centre have been few during the year.

Miss F. Perry, Student Assistant in the Dairy Bacteriology Laboratory, left early in the year to take up another appointment.

General.

Notification has been received that the advisory grant in respect of Agricultural Economics will be increased by £290 per annum for a period of probably not less than five years in order that this centre may participate in a new " Farm Management Survey."

At the request of the British Basic Slag Company, Ltd., the centre has arranged to institute experiments on grassland in order to study the effects of low grade and high grade basic slags. The firm concerned is providing the necessary fertilisers for this experiment and is also contributing a sum of £50 per annum towards their cost.

In accordance with the joint scheme between Advisory Economists and the Milk Marketing Board, the latter body has been supplied with statements of costs of milk production on 58 farms for the summer period and for the whole year. In addition to this, similar costs are being kept upon another 75 farms, making 133 in all. These cost figures have been used as evidence by the Milk Marketing Board in the enquiry which has been proceeding during 1936.

Mr. A. W. Ling, the Agricultural Officer in charge of the Centre, has again been closely concerned with the organisation of the broadcast talks for farmers given regularly throughout the year from the West Regional Station. In addition to these a number of feature programmes of agricultural interest have also been given. From all sides reports indicate the value of this method of establishing touch with the farmers of the Province and of keeping them informed of developments of special interest.

THE LONG ASHTON RESEARCH STATION.

Staff.

Among the staff changes to be recorded at the Station during 1936 is that of Mr. W. Camps, who has acted as personal research assistant to the Director since 1911 and has been senior laboratory steward since the present laboratory was erected in 1913. His is the first case of retirement under the age limit in the Department. Throughout his long association with the Station he rendered invaluable service, and he carries with him in his retirement the best wishes of all who have been associated with him at Long Ashton.

Mr. F. C. Lewis, M.Sc., of the Fruit Products Section, has resigned his appointment on accepting a post in connection with this subject at Dartington Hall. To fill the vacancy in this section created by his departure and to provide much needed assistance on this rapidly developing side of the Station's work, Messrs. N. P. Bridgewater, B.Sc., and R. C. Curtis, B.Sc., have acted as assistants during the year in extension of the temporary arrangements made in their case during the latter part of 1935. Mr. L. T. Darch, B.Sc., also joined this Section for a period during the year. In addition Mr. P. Manelsky, Ph.D., who was temporarily in this country for a few months during 1936, and has had considerable experience of fruit products work in Spain, became attached to this Section as a voluntary worker for a short time until recalled to Spain.

The Assistant Mycologist on the advisory staff, Mr. P. W. Brian, M.A., resigned his post early in the year on receiving an appointment with Imperial Chemical Industries, Ltd., and has been succeeded by Mr. C. J. Hickman, M.Sc., of Birmingham University.

During the latter part of 1935 the special investigations on fungicides and insecticides arranged in conjunction with Imperial Chemical Industries, Ltd., were continued temporarily with the aid of the services of a member of the staff of that firm, following the resignation of Mr. A. C. Evans, B.Sc., early in that year. This temporary arrangement ceased on the appointment of Mr. E. W. Fajans, Ph.D., in January 1936, to a full-time post in connection with this work.

Buildings and Land.

No additions to the permanent buildings at the Station have been made during the year, but the Committee has approved a housing scheme for certain key members of the staff, whose work makes it desirable for them to live on the spot. As the first instalment of this scheme the erection of a house for the Director is being proceeded with.

With practically the whole of the land of the Station suitable for fruit culture now having been fully planted, there is little to record as regards the establishment of new plots. The need for more room for nursery and miscellaneous preparatory work has been met by the removal of a worn-out farm orchard near the north-western boundary of the farm and the enclosure with this land of surrounding hillside land previously used for grazing purposes. The new plot thus provided gives an additional area of approximately three acres to the land now in use for investigations on fruit culture.

General.

Annual Field Day. The Annual Field Day of the Station was held on Thursday, May 7th. Included in the programme, in addition to the sampling of ciders made in connection with the Cider Competitions and the experiments in the cider house for the year, were exhibits showing various forms of fruit products, including fruit-flavoured milk shakes, illustrating recent researches at the Station on this subject. Demonstrations by members of staff were given in the plantations on orchard spraying by means of mobile power spraying outfits; methods of head-working established trees by (i) the customary rind-graft method and (ii) some recently introduced methods; and on the latest developments in materials and methods used in spraying in connection with fruit culture and market gardening. The thanks of the Station are due to the Ministry of Agriculture and Fisheries for the additional interest lent to the occasion by the exhibit relating to the Ministry's National Mark Schemes, which was staged in the cider house.

The special feature associated with the proceedings of the day was a broadcast of certain characteristic features, which was transmitted through the West and Midland Regional Stations to all parts of the Empire. This was the first time that any broadcast of the proceedings had been attempted, and subsequent reports indicate that it aroused much interest.

The attendance was again very large and representative and the weather was, as usual for this particular function, fine. The prizes in the Cider Competitions were distributed by Sir Stephen Tallents, K.C.M.G., C.B., C.M.G., of the Public Relations and Publications Department of the British Broadcasting Corporation, who also made a short speech appropriate to the occasion.

Visit of East Malling Staff. After a lapse of a few years the Station was visited once more by the members of the staff of the East Malling Station to discuss programmes of research and other matters of joint interest to the two Stations. By a happy arrangement the date for the visit was selected so that our visitors were able to arrive during the course of the proceedings of the Annual Field Day. The results of the visit have been very helpful in facilitating working arrangements between the two Stations and enabling the East Malling staff to see the progress of the field experiments at Long Ashton.

Fruit Products. A new feature was added to the various functions of the year in the form of an Open Day for the sampling of various products produced by this Station as the outcome of its recent work on fruit products. This was attended by about 75 manufacturers of fruit products, fruit growers and others interested in this branch of the Station's work. The thanks of the Station are due to the Milk Marketing Board and the Milk Publicity Council for their co-operation in equipping a temporary milk bar for the occasion to enable the products suitable for the preparation of milk shakes to be suitably sampled. The amount of interest shown in the exhibits and the numerous enquiries with regard to them received since have shown the usefulness of the function and have indicated the desirability of its renewal at an early date, when the work on fruit products has reached a further stage.

Also for the Fruit Products Section the year has been noteworthy in seeing the development of some of the Long Ashton products from the laboratory to the commercial scale of production. In this connection a development closely affecting the Station calls for particular reference. The establishment by Messrs. H. W. Carter & Co., Ltd., of Bristol, of a factory at Ashton Gate, Bristol, for the manufacture of fruit syrups according to the Long Ashton method has provided the Fruit Products staff of the Station with an opportunity of observing the problems arising in connection with the production of these syrups on a commercial scale. A working arrangement was arrived at with the firm in question, under which the services of Mr. V. L. S. Charley, the senior member of the staff of the Fruit Products Section, were made available for the technical supervision and control of the factory work. In return the firm provided facilities for the conduct of such experiments as the Station desired to make under factory conditions and, at the same time, permitted the Station to make use of all data obtained during the course of the work. A detailed account of the working methods under this scheme is given in an article by Mr. Charley in the present Report.

Apple Packing. By arrangement with the Ministry of Agriculture and Fisheries an instruction class in apple packing was held at the Station in September, Mr. J. W. Ewan, an Inspector of the Ministry, acting as Instructor. The thanks of the Station are due to the Ministry for the useful service thus given to the members of the fruit packing staff and others connected with the fruit growing industry.

Travelling Fellowship. During the course of the summer of 1936 Mr. R. W. Marsh, the Research Mycologist at the Station, spent three months touring the fruit-growing districts of the eastern part of the United States and Canada. This was made possible by a Travelling Fellowship awarded by the Ministry of Agriculture and Fisheries for the purpose. During the course of his visit he was able to examine more particularly the methods of control of diseases and pests of fruit in those countries and to compare them with those in use in this country.

Visitors and Visiting Parties. Many organised parties of growers, allotment holders' associations and others interested in the work of the Station have visited it during the year, the complete list being as follows :—

Connaught Road Senior Boys' School.
Bishop Road Evening Institute Gardening Classes.
The Chemical Society.
Bristol Unionist Association, West Division.
Bishop Road Evening Institute.
Institute of Amateur Cinematographers.
Surrey Ladies Gardening Club.
Reading University Horticultural Students.
Mr. Oram's party.
Somerset Branch of Surveyors' Institution.
John Millard's Women's Social Hour.
The Isle of Man Forestry Board.
Fishponds Diocesan Training College.
Westbury-on-Trym Branch of the C.E.M.S.
Staff of Messrs. Christopher Thomas Bros., Ltd.
Brislington and District Amateur Gardeners' Association.
Clifton College Scientific Society.
Staffordshire Branch of the National Farmers' Union.
Society for Experimental Biology.
British Mycological Society.
Executive Committee of The Mineral Water Trade Association.
Portishead Ratepayers' Association.
Domestic Fruit and Vegetable Preservation Courses Students.
Bristol University Settlement Class.
Totterdown and Knowle Co-operative Men's Guild.
Malmesbury and District Beekeepers' Association.
International Conference of Agricultural Economists.
E. S. and A. Robinson's Pensioners' Social Club.
Badminton School Girls.
Bristol University Geographical Society.

Show Exhibits. In addition to these parties the Station has received visits from a very large number of individuals, including scientists and horticulturists from all parts of the world.

During 1936 there was an exceptional call on the Station in connection with exhibits to agricultural and other shows. Since the Royal Agricultural Society's Show was held at Ashton Court, Bristol, during this year, it was possible to arrrange for the occasion an exhibit of a specially extensive character. The holding of this Show at Long Ashton also brought a considerable influx of visitors to the Station during that period. The complete list of shows and exhibitions to which exhibits were sent during the year is as follows :—

Devon County Show, Exeter.
Asparagus Show, Evesham.
Bath and West Show, Neath.
Three Counties Show, Worcester.
Cheltenham Floral Fete, Cheltenham.
Royal Agricultural Society's Show, Bristol.
Gillingham and Shaftesbury Show, Gillingham.
Melplash and District Show, Beaminster.
Imperial Fruit Show, Liverpool.
Wine and Food Society, Royal Horticultural Society's Hall, London.
Abergavenny Horse Show, Abergavenny.
Dorset Cider Makers' Federation, Dorchester.

Research Students. A number of post graduate and voluntary workers have studied at the Station during the year. Their help in investigations with which they have been concerned has meant an important contribution to the output of research work. Unfortunately, owing to the limited amount of laboratory accommodation now available, it is not possible to accommodate more than a limited number of such workers, and applications for places have been in excess of the space available. Miss M. Carleton, Ph.D., continued her entomological research investigations, Mr. D. L. G. Davies, B.Sc., his mycological investigations, and Mr. V. G. Vaidya, B.Ag., his work on Agricultural Chemistry. Mr. H. H.Khan,B.Sc., and Mr. Y. V. Rao, M.Sc., two new post-graduate workers, have investigated certain pomological problems, and Mr. E. H. Wilkinson, B.Sc., has been occupied with mycological investigations.

Acknowledgments. Only a very general reference to the work being carried on in collaboration or consultation with other institutions and in conjunction with many commercial fruit growers in different parts of the country can be made here. It is of inestimable value in supplementing the associated investigations in progress at Long Ashton, and the thanks of the Station are due to all the institutions and individuals concerned for the facilities provided and the help rendered in many other ways also.

Acknowledgment should also be made of the loyal support which has been given by all grades of workers at the Station throughout the year.

APPLE BREEDING INVESTIGATIONS.

I.—RESULTS OBTAINED FROM CERTAIN FAMILIES OF SEEDLINGS.

By G. T. SPINKS.

Comparatively little information has hitherto been published on the breeding of apples from English varieties. Saunders, Macoun and Davis, in Canada, and Auchter, Crandall, Lantz and Wellington, among others in the United States, have published accounts of their experiments in breeding apples and have drawn conclusions regarding the inheritance of various characters. Much of the attention of these workers has been directed towards the production of varieties with certain characters, such as hardiness, for which there is no particular need in England, and various species have been used for breeding. When commercial varieties of apples have been used as parents, as in the work of Wellington (4), the varieties have been almost exclusively American sorts which are rarely grown in England.

While the above work may have provided information of value to the geneticist, the English breeder of apples possibly wishes to produce new varieties with some of the best characteristics of English varieties and suitable for growing under our conditions : any information on the results of breeding experiments with English varieties will therefore be of special interest to him. Laxton (3) published brief descriptions of the seedlings obtained from a number of crosses, and Bunyard (1) has drawn attention to conclusions which may be drawn from the work of Laxton and other breeders. The most important publication on this particular aspect of apple breeding is, however, that by Crane and Lawrence (2), who have presented the results found in a number of families of apple seedlings and have analysed them in the light of modern cytological knowledge.

The information in the present paper is largely an addition to that provided by Crane and Lawrence, as different families have been raised, but it has been considered more from the point of view of the practical breeder than from that of the geneticist.

GENERAL ACCOUNT OF THE INVESTIGATIONS.

The main part of the apple-breeding work at Long Ashton was commenced in 1916, though a few families of seedlings had been raised by Professor B. T. P. Barker previous to that date. The primary object of the work was the production of new varieties superior to those then available, and an investigation of the genetics of apples was not contemplated. It was, however, decided to keep detailed records of the fruit and tree characters of all seedlings in the hope that these might furnish genetical information which would be of use in indicating the lines which future work should follow. No cytological work has been done.

In making crosses, the production of dessert varieties was the main objective and combinations of parents which seemed likely to give the desired results were used. A considerable number of crosses between parents of widely differing character were made in order to observe the occurrence of certain well-marked characters in the progeny. Families of seedlings were also raised from open-pollinated seed of a number of varieties, as it was thought that these might indicate whether any of these varieties were of particular value as parents owing to the dominance of good characters : it was also thought that large families of possible value could be raised in this way without the labour of cross-pollination. Varieties which are used only for cider-making were included in the parents employed.

At the time of the inception of this work very little was known of the genetical constitution of apples and the researches of other breeders and cytologists have since shown that the combinations of parents used were not those most likely to yield either the best practical results or the most information on heredity. It would also have been better to have raised a smaller number of families, each containing a large number of individuals, rather than such a large number of small families. The use of triploid varieties as parents, which might have resulted in the production of a number of disappointing seedlings, was avoided, though quite by chance. It so happened that varieties of this type were used only in a very small number of cases. In later work at Long Ashton, programmes have been planned more in accordance with the cytological information now available.

Details of the technique employed in hybridising and in the growing of seedlings need not be given here. Cross-pollination was carried out either in small insect-proof cages in an orchard house or in paper bags on trees in the open. In the earlier years seedlings were worked, as soon as large enough, on layered stocks, or head-worked on older trees, but more recently they have been grown on their own roots and propagated only if they showed promise of practical value. The seedling trees have been grown as "regulated" bush trees, *i.e.* with a minimum of pruning, in order to encourage early fruiting.

Records of various fruit and tree characters, which are tabulated and discussed below, were usually collected until the seedling had borne two or three crops, after which the tree was destroyed unless it appeared to be worth propagating. By the year 1935 the records of all the families raised in the first few years of the work were complete and these are considered in the present paper. Families raised later and not yielding complete records by 1935 are not usually included, but will be the subject of future communications.

The data now presented were obtained from some 1,300 seedlings. Of these, 666 are included in 45 families obtained from controlled crosses. The largest family contains 103 seedlings, another contains 53, while 7 others include more than 20 individuals. In 23 families, however, the numbers are less than 10 and the data from these are not included in the tables, though in some cases reference is made to them in the text. Plants from open-pollinated seed number 630 and comprise 24 families, some of the largest of which include 135, 75, 55 and 52 seedlings. The data obtained from these families have been considered in drawing conclusions but are only included in the tables in the case of families of special interest.

All the available data have been analysed and are presented in the form of tables. Each character is considered separately in the succeeding sections.

ANALYSIS OF RESULTS.

Fruit Characters.

Fruit Shape. (Table I).

The shape of fruits has been indicated here by a figure which shows the ratio of the longitudinal diameter to the transverse diameter, expressed as a percentage. Thus, the figure 100 indicates a round fruit, a figure less than 100 a more or less flattened fruit, and a figure greater than 100 a long fruit. Actually, a fruit with the figure 100 gives a visual impression of a rather long fruit, while a fruit which appears round to the eye shows a figure of between 90 and 95.

The small numbers of fruits shown under the figure 95 is due to the measurements being taken only to the nearest quarter-inch. A more accurate system of measuring and tabulating would have shown that some of the fruits recorded under the figures 100 and 90 were actually of an intermediate shape. For the same reason, and also on account of the small size of some families, it would be unwise to lay too much stress on the details of the frequency distributions shown in the table.

The data, however, show that the fruits in each family usually exhibit a range in shape equal to, or greater than, that between the parents. There are few fruits near the ends of the range and the largest number occur near the middle of the range. For instance, in the family Stirling Castle × Morgan Sweet, where the shapes of the parents are expressed by the figures 70 and 100, only 10 seedlings show figures of more than 90 and 9 seedlings of less than 80, while 34 occur between 90 and 80. The mean figure for any family, however, is usually not equal to the mean for the two parents, but is slightly nearer to the figure 90 which indicates an apparently round fruit. Thus, in the above family the mean for the parents is 85, but that for the seedlings is 88.

It appears, therefore, that long or short-fruited parents are likely to produce a fair proportion of seedlings with similarly shaped fruits, but when the parents have fruits of different shapes there is a tendency towards the formation of a round fruit. Unfortunately the families under review contain very few examples of short × short or long × long combinations.

Varieties which have produced the largest proportion of short-fruited seedlings are Beauty of Bath, Court Pendu Plat, Devonshire Quarrenden and Wellington, while long fruits have been obtained chiefly from the progeny of Allington Pippin, Lord Derby, Lord Hindlip and Morgan Sweet.

Fruits, whether long or short, may show different shapes when seen in longitudinal section. In some cases the fruit is of the same width near the eye as near the stalk and such fruits are circular, oval or roughly rectangular in section. Other fruits, however, are narrower towards the eye, with the result that the section tends to be roughly triangular, and fruits of this character are here described as conical. A few varieties are distinctly conical in shape, but in others the narrowing toward the eye is either slight or entirely absent. In studying the families of seedlings an attempt was made to record this character of conical shape, the fruits being classified as distinctly conical, slightly conical or not conical (*Table II*). It was found that about one quarter of the total number of seedlings bore fruit showing any tendency to a conical shape and in only one-third of these was the fruit distinctly conical. The proportion of conical fruit was different in the various families and it appears that some parents are more likely than others to transmit this character. Crosses between slightly conical parents or between distinctly conical and non-conical varieties have usually produced the normal proportion of conical fruits. A large proportion of conical fruits appeared in the family from a cross between two conical varieties, Cap of Liberty and M3E (a seedling variety), and also in the seedlings from open-pollinated Lord Derby. Conical fruits, however, were rare among the progeny of two non-conical parents and seedlings derived from such varieties as Beauty of Bath, Court Pendu Plat and Wellington have produced only a small number of conical fruits.

Apples, as seen in a transverse section, may be either regular in outline or more or less distinctly angular. In the seedlings under review the total numbers of regular and slightly angular fruits were about equal, while distinctly angular fruits were much less numerous (*Table II*). Distinctly angular or regular parents have shown a tendency to produce seedling fruits with the same respective shapes. Thus, several small families with Lord Derby as one parent include a large proportion of seedlings with angular fruits but only a small number with regular fruits : seedlings derived from Court Pendu Plat, on the other hand, show a large proportion of regular fruits, especially when the other parent is also a regular-fruited variety such as Wellington or Cox's Orange Pippin. It is perhaps worthy of note that seedlings with Wealthy as one parent gave a large number of slightly angular fruits, though Wealthy itself is regular in shape.

Fruit Size. (Table III).

The size of fruits has been judged from the measurement of the transverse diameter. Although actual measurements have been made there is considerable room for error in a consideration of the figures obtained, as the measurements are merely those of what were considered to be "typical" fruits of each seedling variety and in many cases only a small number of fruits were available. Statistically significant figures are also wanting as regards the sizes of the parent varieties, the dimensions in this case also being those of "typical" fruits. It is evident that the figures available can only give a rough idea of the heredity of fruit size.

There is a considerable range of size in the fruits borne in any one family, fruits smaller than those of either parent being fairly common, though fruits larger than those of either parent occur much less frequently. The average size of fruit in a seedling family is usually slightly less than the mean size for the two parents but the significance of this difference in the present instance is doubtful, as the rather low standard of culture and absence of pruning of the seedling trees is likely to result in smaller fruit. The mode of the seedling sizes is always approximately equal to their mean. None of the families examined show any appreciable deviation from a graded inheritance of the size of the two parents.

Fruit Colour. (Table IV).

An exhaustive examination of fruit colour would be a complicated matter and is outside the scope of this paper. The colour observed depends on both the red pigment and the ground colour of the skin. the latter colour again depending on the stage of ripeness of the fruit when examined. The colours actually observed were noted in every case—*e.g.* crimson, scarlet, brownish-red—but were not checked against any standard colours and the records of these are therefore probably of little value from a strictly scientific point of view : also, the records do not always distinguish clearly between the extent and intensity of pigmentation, but it can be assumed that the observations made here refer in general to the intensity of the colour. Stripes of colour are sometimes present and these may occur either with or without a general flush of colour, but in the present account reference to striping is made only in particular cases.

In all the families considered here there appears to be a continuous gradation of colour and the average amount of colour in the seedlings of a family is proportional to the colours of the two parents. Thus, a family of 29 seedlings obtained by crossing the variety Devonshire Quarrenden with Cox's Orange Pippin contained 11 with dark or very dark red fruits, 11 with moderate colour, 4 with poor colour and 3 with no red colour. Allington Pippin crossed with Worcester Pearmain produced 5 highly coloured seedlings out of 30, while Worcester Pearmain × Beauty of Bath gave 7 out of 18. The seedlings under review contain no examples of crosses between two highly coloured parents.

Most of the parents were moderately coloured and their progeny included a smaller proportion of plants with highly coloured fruit. Parents showing no colour, or only a small amount, produced a large proportion of seedlings with similar characteristics, *e.g.* :—

Lord Derby open-pollinated (14 seedlings) ..	3 poor colour, 11 none.
Wellington × Lord Derby (9)	6 poor colour, 3 none.
Wellington × Ecklinville (19)	11 poor colour, 4 none.
Stirling Castle × Morgan Sweet (50).. ..	24 poor colour, 17 none.

In open-pollinated seedlings the male parent is, of course, unknown, but it is perhaps worthy of note that 64 such seedlings from Allington Pippin included 31 with highly coloured fruit, while from Cox's Orange Pippin the numbers were 3 out of 119, from Bismarck 5 out of 48 and from Worcester Pearmain 5 out of 15.

Stripes were of fairly frequent occurrence, usually in combination with a flush, the numbers of fruits bearing stripes only being very small. The parents giving the highest proportion of striped fruits are Allington Pippin, Beauty of Bath, Wealthy and Worcester Pearmain, the striped and flushed fruits being about equal in number to those with a flush only. The family Devonshire Quarrenden × Cox's Orange Pippin included only 3 striped fruits out of 26.

Ground Colour of Fruit Skin. (Table V).

The ground colour of the skin was classified as dark yellow, pale yellow, white or green. It is difficult to assess this character correctly, even in the parents, as in any one variety it varies, not only with the stage of ripeness of the fruit, but also with the conditions of culture and nutrition under which the trees are grown. In the case of the parents the colour given in the table is that of an "average" fruit which has attained its climacteric or state of full ripeness in storage. It is doubtful whether all the seedling fruits examined had reached this state. The proportion of fruits classed as green is therefore probably much too high, as many of these might have been placed in one of the other classes when quite mature.

White ground colour was rarely found and dark yellow was less common than pale yellow. Dark yellow skin occurred in families where both parents were pale in colour, but was more frequent in families where one or both parents were dark. Medaille d'Or × Kingston Black produced many fruits with dark yellow colour and Court Pendu Plat evidently transmitted this character strongly, except in the cross with the white-skinned Sweet Alford. Other families derived from Sweet Alford tended to be pale in colour, while Bismarck, Gascoyne, Lord Derby and Morgan Sweet also produced a high proportion of seedlings with pale yellow skins.

Russet. (Table V).

As the amount of russet on any one variety of apple is affected by such factors as weather and spray treatment, observations on the russet occurring on a number of different seedling varieties must be regarded as being only approximately correct. In the various families examined the majority of the parents bear fruits on which russet is either absent or present in quite small quantities. The fruits of the large majority of seedlings derived from such parents are quite smooth, though in a smaller number of cases the fruit is slightly russeted : seedlings with distinctly russet fruit have occasionally been derived from such parents but the number of these is very small.

Parents with a large amount of russet have produced a larger proportion of seedlings of a similar character, notable examples of these being Medaille d'Or and the seedling M3E (derived from Medaille d'Or). Other families with a fairly high proportion of russet fruits are :—Court Pendu Plat × Cox, Court Pendu Plat × Wellington and Sturmer Pippin × Cox's Orange Pippin. No families have been raised in which both the parents bear distinctly russet fruit.

Flesh. (Table VI).

Flesh colours of the seedling apples have been classified as yellow, cream, white and green, though naturally cases occur in which the classification is rather doubtful. In the great majority of families cream flesh occurs most commonly. Yellow-fleshed fruits are most abundant in the families having Court Pendu Plat as a parent, the proportion being high in every case except that of the seedlings from Court Pendu Plat × Sweet Alford. Cox's Orange Pippin and Allington Pippin have produced a fairly high proportion of yellow flesh, especially when crossed with varieties with cream or yellow flesh. Bismarck seems to be the variety which is most prone to produce seedlings with white or greenish flesh, though the family Medaille d'Or × Kingston Black also produced a large proportion of such fruits.

The texture of the flesh has been described as crisp, tough or soft, and, of these, crisp flesh occurs most commonly in the majority of families, while soft flesh is comparatively rare. Tough flesh has appeared most frequently in seedlings derived from Court Pendu Plat, while Worcester Pearmain has also transmitted this character fairly frequently, though not in the family Worcester Pearmain × Beauty of Bath. The tough-fleshed varieties Medaille d'Or and M3E (also derived from Medaille d'Or) have produced a large proportion of seedlings with tough fruits.

The fruits of seedlings were graded according to their juiciness, the three classes recognized containing those with much, moderate and little juice respectively. The intermediate class is much the largest in almost every family and apples lacking in juice are more numerous than those with much juice. There are few outstanding differences between the various families, and it can scarcely be said that any one parent shows a tendency to produce seedlings with much or little juice. Possibly, however, Court Pendu Plat, Worcester Pearmain and Morgan Sweet have produced the largest proportion of fruits lacking in juice, while Wealthy and Wellington have given rise to more juicy fruits.

Flavour. (Table VII).

In making notes on the flavour of the fruits the three questions of sugar, acid and aroma have been considered. An attempt has been made to assess the amounts of sugar and acid separately, as the impression of sourness or sweetness received by the palate depends on both these substances, but it is a difficult matter to do this by taste. Chemical analysis of fruits of parent varieties indicates that the range of acidity is much greater than that of sugar content and the sensation of sweetness appears to be influenced more by the acidity than by the actual amount of sugar present. In some of the families, *e.g.* Stirling Castle × Morgan Sweet and Medaille d'Or × Kingston Black, parents with differing amounts of acid or sugar had been crossed with the object of determining the inheritance of acidity or sweetness. The latter family also affords an opportunity to study the inheritance of the tannin content of the fruit.

In most families the seedlings seem to contain, on the average, about the same amount of sugar as the parents. Thus, crosses between two dessert apples have usually produced a majority of seedlings with a high sugar content, a smaller number with moderate sugar and a very small number which are deficient in sugar. The variety Worcester Pearmain, in the crosses with Allington Pippin and Beauty of Bath, has produced a large proportion of seedlings containing abundant sugar. Cox's Orange Pippin and Medaille d'Or are other parents which have transmitted a high sugar content to many of their progeny. Morgan Sweet (medium sugar) crossed with Stirling Castle (low sugar) has produced seedlings with high, moderate and low sugar respectively roughly in the ratio of 1, 2 and 1 ; but seedlings of the former variety crossed with Newton Wonder include no apples with poor sugar. The seedlings derived from Sweet Alford crossed with other sweet varieties, however, do not include a large number of very sweet fruits. Parents such as Bismarck, Lord Derby and Wellington have given rise to a larger proportion of fruits with low sugar, while high sugar content is found in only a few of their seedlings.

The inheritance of acidity follows much the same lines as that of sweetness. The majority of seedlings are of medium acidity. Families derived from Worcester Pearmain have a tendency to low acidity, while those from Bismarck, Lord Derby and Wellington contain more acid fruits. The family Stirling Castle × Morgan Sweet contains rather more low-acid than high-acid seedlings. Seedlings from Sweet Alford are notable for the large proportion of fruits which were classed as high-acid in the cross with Wealthy.

The aroma of the seedling fruits was considered from the point of view of their suitability for dessert and some fruits may therefore have been put in a low grade for aroma even though they were excellent for cooking. It was found that the aroma of about 57% of the total number of seedlings was classed as poor, 37% as moderate and only 6% as good. The apples in the " good " class included a few of really excellent flavour and others in which the flavour was " fairly good," though not first-class. No fruit which was not at least " fairly good " was considered to be worth propagating for further trial as a dessert fruit. The figures in the table show that in no case do any seedlings of a family appear in the "good " class unless at least one of the parents has a good aroma. Of the 52 seedlings in this class 22 were obtained from crosses in which both parents were recognised dessert varieties, though not always of first-class quality, 8 from crosses between dessert and other varieties, while 22 were derived from open-pollinated dessert varieties. The varieties which have been most successful in transmitting a good aroma to their seedlings are Cox's Orange Pippin, Beauty of Bath and Court Pendu Plat, these being followed by Allington Pippin, Worcester Pearmain and Wealthy. The majority of the seedlings from Worcester Pearmain were obtained from crosses with Allington Pippin and Beauty of Bath, and this may account for the apparently good performance of this variety. In the case of Wealthy, 72 seedlings from this variety crossed with the poor-flavoured Sweet Alford included only one of good flavour, but 30 other seedlings of Wealthy included 4 with a good aroma, suggesting that the variety is fairly successful in transmitting aroma. It is worthy of note that the family Court Pendu Plat × Wellington contains a large proportion of individuals with a good flavour.

In the two families Medaille d'Or × Kingston Black and Cap of Liberty × M3E, the two varieties with a high tannin content have transmitted this character to all their seedlings, though the tannin is not always as abundant in the seedlings as in the parents. Tannin has not been noted in any other seedlings except a few derived from parents in which there is an appreciable tannin content.

Season of Use. (Table VIII).

In tabulating the season of the seedlings the beginning, but not the duration, of the season has been indicated. This should be borne in mind, particularly in the case of the later varieties, when comparing the season of the seedlings with that of the parent varieties, for which the middle of the season of use has been shown in the table.

In every family the season of ripening of the seedlings shows a considerable range, the largest number of individuals occupying the middle of the range and the numbers decreasing towards both extremes. The average season of seedlings is often about the average of that of their parents but the extremes in some families extend beyond the seasons of one or both of the parents. In general, each parent tends to transmit its same season of ripening, but there is no definite segregation of this character. A definite tendency towards an early season is found in seedlings of Beauty of Bath, whether open-pollinated or crossed with Cox's Orange Pippin or Worcester Pearmain. On the other hand, Court Pendu Plat, Sturmer Pippin and Wellington have exercised a distinct influence in the direction of late ripening in every family in which they were used as parents.

Use of Seedling Fruits. (Table IX).

All seedlings have been classified according to their suitability for dessert or culinary purposes. Many fruits have been placed in one or other of these classes even though their quality is distinctly below that desirable in the class in question ; but a considerable number of seedlings have borne fruit which appears unsuitable for any purpose and these have been classed as useless. A few fruits were thought to be suitable only for cider-making and these were mainly derived from parents which were recognised cider varieties, though a few instances of such fruit have occurred in families obtained from market varieties.

As recorded above, seedling fruits tend to resemble their parents in sweetness, acidity and aroma, and as the use of a fruit is determined largely by a combination of these qualities it is not surprising to find that the use of seedling varieties follows closely that of their parents. Crosses between two dessert varieties have been found to result in a majority of seedlings suitable for dessert and very few which were classed as culinary. Similarly, cooking varieties, when used as parents, have produced mainly cooking apples and very few dessert varieties. A certain number of useless seedlings have appeared in both these cases but occur much more frequently in crosses between dessert and cooking varieties. The largest proportion of useless fruits have been found in families of open-pollinated seedlings and of crosses between market and cider varieties. It is perhaps notable that in the family Court Pendu Plat × Wellington 18 seedlings were classed as dessert, none as culinary, and 17 as useless : a large number of these fruits were very tough in texture and were classed as useless on that account.

Time of Blossoming. (Table X).

The time of blossoming of a variety may be of considerable importance from the practical point of view, for, in general, the later the bloom the greater chance there is of escaping frost damage. Dates of blossoming, either first bloom or full bloom, have therefore been noted for all seedlings. The records show that the range of dates for any family is usually about the same as that between the two parents. Seedlings derived from two parents, both of which flower in mid-season, rarely include any distinctly early or late-blossoming trees. One notable exception to this has been found, however, the earliest variety of any in the Long Ashton plantations being a cross between Allington Pippin and Star of Devon, both of which are mid-season. Many of the seedlings derived from Cox's Orange Pippin also differ considerably from their parents, being later in blossoming than would be expected. There is no doubt that late and early varieties tend to produce seedlings resembling the parents in time of blossoming. The very late variety Court Pendu Plat has shown its influence in every family of which it is a parent, a large proportion of the seedlings flowering fairly late and some of them as late as the parent. Such late-blossoming trees are very noticeable in the plantation, not only when in bloom but also previous to this time, as they are also very late in bud-break and foliage production. Unfortunately the blossom records of the family derived from the extraordinarily late variety Medaille d'Or are rather incomplete, but this variety also seems to have transmitted a late-flowering character to most of its seedlings.

The effect of an early-flowering parent is perhaps less marked, but there is a distinct tendency to earliness in seedlings from Beauty of Bath and Bismarck. The family Stirling Castle (early) × Morgan Sweet (moderately late) includes a few early and moderately late seedlings, but the majority are mid-season.

Tree Characters.

Size. (Table XI).

Seedling trees have been classified, when about ten years old, as large, medium or small, the classification being made by eye only. The greatest number of trees were classified as medium, while large trees are almost as numerous. The class of small trees contains the smallest number. The proportions are roughly the same in most of the families, though exceptions occur. The various soil conditions under which the trees were grown, the method of estimating size, and the possible variation in the standards adopted from year to year prevent any reliable conclusions being drawn from the records. The data do not suggest that there is any correlation between the size, or vigour, of seedlings and that of their parents. Only four of the seedlings under consideration were derived from a triploid parent (Court Pendu Plat × Blenheim Orange) and all of these were classified as large. The records show, however, that this cross yielded 25 seeds, of which 6 produced seedlings, but apparently only 4 survived to bear fruit.

Habit. (Table XI).

From inspection, seedling trees have been classed as erect, medium or spreading in habit. In every case the observations were made on comparatively young trees, say 10 years old, which had not borne heavy crops. Representatives of each class appear in almost every family, trees of medium habit being usually the most numerous and spreading trees least common. Although parental influences are not very marked there appears to be a tendency towards an erect habit in seedlings derived from Court Pendu Plat (especially in the cross with Wellington), Reinette Obry, Worcester Pearmain, Wealthy and Lord Derby. A spreading habit is more common in some families derived from Allington Pippin and Bismarck.

Sturdiness.

An attempt was made to classify seedlings according to the sturdiness of their branches, the classes recognised being sturdy or stout, moderate and spindly or slender. In the great majority of families the numbers occurring in the three classes were roughly in the ratios 1 : 2 : 1. In some cases, where distinctly different ratios were found the smallness of the total numbers make the observations of doubtful value. The only families worthy of special mention appear to be Devonshire Quarrenden × Cox's Orange Pippin and Stirling Castle × Morgan Sweet, both of which included a large proportion of spindly trees, and Lord Derby open-pollinated, which included a fairly high proportion of trees in the sturdy class, but none classed as spindly.

Number of Lateral Branches.

A classification of seedlings according to the number of lateral branches which occurred on almost unpruned trees gives a result very similar to that noted in the previous section, trees with a moderate number of laterals being usually about twice as numerous as those with either many or few laterals. A tendency to the production of a large number of branches occurs in the families Allington Pippin open-pollinated, Devonshire Quarrenden × Cox's Orange Pippin, Stirling Castle × Morgan Sweet, Court Pendu Plat × Wellington, while the reverse is found in Bismarck open-pollinated.

Spur Formation.

The relative abundance of naturally-formed spurs on the seedlings was noted and, in general, it may be said that on the majority of seedlings spurs are present in large numbers, while they are few or only moderate in numbers on others. A few families appear to include an unusually high proportion of trees with abundant spurs but this character cannot be ascribed to the influence of any particular parent. On the other hand, Worcester Pearmain when crossed with Allington Pippin and Beauty of Bath has produced a large proportion of trees on which few spurs are formed.

The figures indicating sturdiness, number of branches and spur formation are not presented in tabular form.

Susceptibility to Diseases.

The incidence of several fungus diseases on the seedlings was observed for a number of years and the extent of the attack on the members of each family was noted as being bad, moderate, slight or none. Trees on which no attack of a particular fungus was found are not necessarily immune, but are probably resistant, as all trees had approximately the same chance of being naturally infected.

Mildew. (Table XII).

Attacks of mildew have been of the same order of severity in a number of families, moderately or slightly attacked trees being most common, though a few trees with no mildew or with severe attacks have also occurred. Parents which appear to have transmitted extreme susceptibility to mildew include Allington Pippin, Bismarck and possibly Cox's Orange Pippin and Wellington. Trees in the families derived from Worcester Pearmain are distinctly less susceptible than the average, while Beauty of Bath, Court Pendu Plat, Wealthy and Lord Derby seem to have transmitted some degree of resistance.

Scab. (Table XII).

Scab attacks show a similar range to those of mildew, but a larger proportion of seedlings have been free from this disease. No families are outstanding as regards either susceptibility or resistance, but apparently Devonshire Quarrenden has yielded the most susceptible seedlings. The family Court Pendu Plat × Wellington was rather badly attacked, though none of the other families derived from either of these parents showed great susceptibility. Seedlings derived from Beauty of Bath, Morgan Sweet, Sweet Alford and Wealthy were among the more resistant.

Canker. (Table XII).

Canker has not been of frequent occurrence. The parents with the worst record appear to be Court Pendu Plat and Worcester Pearmain, while Medaille d'Or × Kingston Black and Lord Derby open-pollinated have also included a large proportion of cankered seedlings.

Selection. (Table XIII).

When considering the possible value of any seedling for general cultivation all the points already mentioned in this paper, and possibly others, must be borne in mind. Not only the character and season of the fruits, but also the vigour, habit of growth, fruitfulness and susceptibility to disease of the tree are of importance. As a decision must be taken in the first place on the performance of a single tree growing on its own roots, the tree characters have received only secondary consideration, as they may be modified by rootstock or soil influence. Seedlings with satisfactory fruit characters have therefore been selected for further trial unless the trees exhibit some abnormality of growth or extreme susceptibility to disease.

From the 1,300 seedlings under review 40 have been propagated. This does not imply that these were all considered to be of first class quality, but only that they were worth a further trial. The varieties propagated include 25 dessert, 13 culinary and 2 which it was thought might be useful additions to the range of cider apples. Several of the selected seedling varieties, having cropped for several years on the young propagated trees, have already been discarded as unsuitable for introduction as new varieties. The selected seedlings represent a number of different families, the parents most frequently represented among the seedling dessert varieties being Cox's Orange Pippin, Allington Pippin, Wealthy and Beauty of Bath. Four of the culinary varieties are derived from Lord Derby as one parent. Five dessert varieties have been named and distributed on a small scale, but it is still too early for any reports on their merits to have been received.

DISCUSSION.

The data presented in the preceding sections show that in the families of apple seedlings considered the variation of every character is continuous. In no case has there been a definite segregation of any particular character nor any indication of complete dominance. Families derived from a parent with any strongly-marked character have always included seedlings with similar characteristics but have also shown a gradation of the character in the members of the family. Unfortunately most of the families have been derived from parents of rather widely differing characters and in no case has a particular character been strongly marked in both parents. The numbers in most of the families are also rather small. Nevertheless, the results available are in agreement with those obtained by Crane and Lawrence from different families of apple seedlings and support the view that apples have the genetical constitution of polyploids in which several chromosomes are concerned with the transmission of any one character, so that a variety may contain anything from 0 to 6 " doses " of a character (in the case of " diploid " varieties). The crossing of varieties of opposite, rather than of similar, types has been unfavourable to the determination of the extent to which they are homozygous for particular characters, but in the majority of cases they appear to be heterozygous.

From the point of view of the practical fruit breeder the data show that any cross is likely to result in a few seedlings resembling one or other of the parents in particular respects, but that the majority of the progeny will be intermediate in character. Parents in which characters are strongly marked have been found to produce a larger proportion of seedlings exhibiting these characters. This applies to almost all the points investigated, such as shape, colour, flavour and texture of fruit, season of blossoming and fruit ripening, habit of tree and susceptibility to diseases. The following varieties may be mentioned as examples of those which have transmitted particular characters in a marked degree:—Beauty of Bath, Bismarck, Court Pendu Plat, Devonshire Quarrenden, Lord Derby, Medaille d'Or, Wealthy and Worcester Pearmain.

These facts suggest that every character desired in a seedling should, as far as possible, be strongly marked in *both* parents, and that crosses between similar parents are likely to produce a much larger proportion of seedlings in which the character is present or even intensified. Although it may be possible for a cross between unlike parents to produce a seedling in which a certain character is pronounced, the chances of this occurring are small and would entail the raising of very large families. Crosses between unlike parents, in fact, produce a large number of seedlings in which characters are "diluted" and such varieties are usually unsatisfactory for any purpose: crosses between dessert and culinary varieties, for instance, have resulted in seedlings of indefinite character. The desirability of using "like" parents has already been affirmed by other apple breeders.

The possible results of using other species or uncultivated "varieties" which may be more homozygous, is not discussed here, the present paper dealing almost entirely with seedlings raised from varieties commonly cultivated in England.

SUMMARY.

The inheritance of various characters has been studied in 1,300 apple seedlings, included in 69 families, raised from the seed of dessert, culinary and cider varieties.

The points investigated include fruit character, tree character, season of blossom and fruit, and susceptibility to diseases.

No sharply discontinuous segregation of any character has been found in any family.

Varieties with the most strongly marked characters have produced the largest proportion of seedlings showing similar characters.

The results observed support the view that most of the characters considered are influenced by polymeric factors.

It is suggested that the practical breeder using cultivated varieties of apples as parents should avoid crosses between unlike varieties and that, as far as possible, both parents of a cross should have all desirable characters well-marked.

A number of seedlings of possible value have been selected and propagated.

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TABLE I.

SHAPE OF FRUIT $\left(\frac{\text{LENGTH} \times 100.}{\text{BREADTH}}\right)$

Parents.		*Fruit Shapes of the two Parents.*	*Number of Seedlings of each Shape.*							
			110	100	95	90	85	80	75	70
Allington Pippin	× Red Astrachan	100 : 90	–	2	–	4	1	1	1	–
,, ,,	× Star of Devon	100 : 77	–	2	–	6	2	6	3	–
,, ,,	× Worcester	100 : 95	–	8	1	11	5	5	–	–
,, ,,	open-pollinated	100 :	4	17	–	32	6	6	9	1
American Mother	× Cox's Orange	100 : 83	1	1	–	2	1	2	1	–
Bismarck	× Hollandbury	90 : 95	–	2	–	1	4	3	4	–
,,	× Jonathan	90 : 100	–	2	–	6	–	4	–	–
,,	open-pollinated	90 :	–	1	2	15	8	12	6	3
Cap of Liberty	× M3E	100 : 90	–	7	–	5	4	1	–	–
Court Pendu	× Cox's Orange	70 : 83	–	–	–	3	4	3	5	1
,, ,,	× Dabinett	70 : 85	–	–	–	2	–	3	5	–
,, ,,	× Sweet Alford	70 : 80	–	1	–	7	1	6	5	–
,, ,,	× Wellington	70 : 75	–	–	–	9	3	10	11	3
Cox's Orange	× Beauty of Bath	83 : 77	–	–	–	2	1	2	2	–
,, ,,	× Reinette Obry	83 : 85	–	–	–	10	–	1	2	–
,, ,,	× Wealthy	83 : 85	–	5	–	10	–	1	–	1
,, ,,	open-pollinated	83 :	3	33	–	53	9	24	10	–
Devon Quarrenden	× Cox's Orange	70 : 83	–	1	–	10	1	8	8	1
Gascoyne's S.	× Wellington	100 : 75	–	–	–	6	1	1	3	–
Lord Derby	open-pollinated	95 :	1	2	4	4	3	–	–	–
Medaille d'Or	× Kingston Black	85 : 90	1	10	–	12	1	3	–	1
Newton Wonder	× Lord Derby	80 : 100	–	1	–	–	3	1	–	–
,, ,,	× Morgan Sweet	80 : 100	–	2	–	5	1	4	1	–
Stirling Castle	× Morgan Sweet	70 : 100	2	7	1	23	4	7	8	1
Sturmer Pippin	× Sweet Alford	75 : 80	–	1	–	6	1	1	5	–
Wealthy	× Sweet Alford	85 : 80	–	5	–	31	6	19	12	1
,,	open-pollinated	85 :	–	2	1	5	3	5	–	–
Wellington	× Ecklinville	75 : 80	–	2	–	8	2	5	2	–
,,	× Lord Derby	75 : 100	–	1	–	6	–	2	–	–
Worcester	× Beauty of Bath	90 : 70	–	–	–	6	5	5	6	–
,,	open-pollinated	90 :	2	–	–	4	3	3	3	–

TABLE II.

FRUIT SHAPE, LONGITUDINAL AND TRANSVERSE.

Parents.		*Shapes of the Parents.**	*Number of Seedlings.*					
			Conical (c)	*Slightly conical* (sc)	*Not conical* (o)	*Angular* (a)	*Slightly angular* (sa)	*Not angular* (o)
Allington Pippin	× Red Astrachan ..	c,o : o,o	–	1	8	–	2	7
,, ,,	× Star of Devon ..	c,o : c,o	–	3	16	–	8	11
,, ,,	× Worcester ..	c,o : c,o	4	6	20	–	8	22
,, ,,	open-pollinated ..	c,o :	22	2	51	7	25	45
American Mother	× Cox's Orange ..	c,sa : sc,o	1	3	7	–	5	3
Bismarck	× Hollandbury ..	c,a : c,sa	1	8	5	2	10	2
,,	× Jonathan ..	c,a : o,o	1	5	6	2	8	2
,,	open-pollinated ..	c,a :	3	10	36	11	32	5
Cap of Liberty	× M3E	c,o : c,o	5	7	5	–	6	8
Court Pendu	× Cox's Orange ..	o,o : sc,o	–	1	15	–	3	13
,, ,,	× Dabinett	o,o : o,o	–	3	7	–	7	3
,, ,,	× Sweet Alford ..	o,o : c,sa	–	1	19	–	5	16
,, ,,	× Wellington ..	o,o : o,o	–	2	34	–	6	29
Cox's Orange	× Beauty of Bath ..	sc,o : o,o	1	–	8	2	–	5
,, ,,	× Reinette Obry ..	sc,o : o,sa	–	1	12	–	3	10
,, ,,	× Wealthy	sc,o : o,o	–	7	10	–	10	5
,, ,,	open-pollinated ..	sc,o :	41	7	85	20	61	52
Devon Quarrenden	× Cox's Orange ..	o,sa : sc,o	–	5	24	1	15	13
Gascoyne's S.	× Wellington ..	o,sa : o,o	–	3	8	1	5	5
Lord Derby	open-pollinated ..	c,a :	–	12	2	3	9	2
Medaille d'Or	× Kingston Black ..	o,o : c,sa	4	16	7	–	16	12
Newton Wonder	× Lord Derby ..	o,o : c,a	–	3	2	3	1	1
,, ,,	× Morgan Sweet ..	o,o : c,sa	–	4	9	1	7	5
Stirling Castle	× Morgan Sweet ..	o,o : c,sa	3	19	40	7	34	12
Sturmer Pippin	× Sweet Alford ..	c,o : c,sa	1	2	11	2	8	4
Wealthy	× Sweet Alford ..	o,o : c,sa	2	11	60	4	51	18
,,	open-pollinated ..	o,o :	1	5	10	–	10	6
Wellington	× Ecklinville ..	o,o : o,o	–	2	17	3	14	2
,,	× Lord Derby ..	o,o : c,a	1	1	7	–	6	3
Worcester	× Beauty of Bath ..	c,o : o,o	–	2	20	–	11	10
,,	open-pollinated ..	c,o :	–	1	14	–	6	9

* The shapes of the parents are indicated by the letters given under the shapes of the seedlings. *e.g.*, Allington Pippin × Red Astrachan—c,o : o,o indicates :—Allington Pippin—conical, not angular. Red Astrachan—not conical, not angular.

TABLE III.

FRUIT SIZE: TRANSVERSE DIAMETER (INCHES).

Parents.		*Diameters of Parents (inches).*	*Number of Seedlings.*					
			1.75	2.0	2.25	2.5	2.75	3.0+(*inches*)
Allington Pippin	× Red Astrachan ..	2.5 : 2.5	–	3	4	–	1	1
,, ,,	× Star of Devon ..	2.5 : 2.25	3	3	8	3	2	–
,, ,,	× Worcester ..	2.5 : 2.5	2	4	10	7	3	2
,, ,,	open-pollinated ..	2.5 :	6	13	18	17	13	8
American Mother	× Cox's Orange ..	2.25 : 2.25	–	1	4	3	–	–
Bismarck	× Hollandbury ..	2.75 : 3.5	–	–	1	–	1	9
,,	× Jonathan	2.75 : 2.5	–	2	4	2	4	–
,,	open-pollinated ..	2.75 :	–	–	12	14	13	8
Cap of Liberty	× M3E	2.0 : 2.0	9	5	3	–	–	–
Court Pendu	× Cox's Orange ..	2.5 : 2.25	3	2	6	3	1	1
,, ,,	× Dabinett	2.5 : 2.25	–	–	5	3	2	–
,, ,,	× Sweet Alford ..	2.5 : 2.5	–	7	7	6	1	–
,, ,,	× Wellington ..	2.5 : 2.75	1	5	16	10	1	3
Cox's Orange	× Beauty of Bath ..	2.25 : 2.5	2	2	3	–	–	–
,, ,,	× Reinette Obry ..	2.25 : 2.25	–	5	6	1	1	–
,, ,,	× Wealthy	2.25 : 3.0	–	6	9	–	2	–
,, ,,	open-pollinated ..	2.25 :	10	16	37	37	25	7
Devon Quarrenden	× Cox's Orange ..	2.5 : 2.25	1	10	8	8	2	–
Gascoyne's S.	× Wellington ..	2.75 : 2.75	1	1	3	3	3	–
Lord Derby	open-pollinated ..	3.5 :	–	–	1	1	2	10
Medaille d'Or	× Kingston Black ..	1.75 : 2.25	13	6	6	3	–	–
Newton Wonder	× Lord Derby ..	3.25 : 3.5	1	–	–	–	1	3
,, ,,	× Morgan Sweet ..	3.25 : 2.5	–	2	7	2	1	1
Stirling Castle	× Morgan Sweet ..	3.5 : 2.5	–	8	20	15	7	4
Sturmer Pippin	× Sweet Alford ..	2.75 : 2.5	–	–	8	3	3	–
Wealthy ..	× Sweet Alford ..	3.0 : 2.5	1	8	34	26	3	1
,, ..	open-pollinated ..	3.0 :	–	1	2	3	5	5
Wellington	× Ecklinville ..	2.75 : 3.25	–	3	6	6	2	2
,,	× Lord Derby ..	2.75 : 3.5	–	–	2	4	3	–
Worcester	× Beauty of Bath ..	2.5 : 2.5	4	7	6	2	1	–
,,	open-pollinated ..	2.5 :	–	1	7	3	2	2

TABLE IV.

Red Colour of Fruit.

Parents.		Colours of Parents.	Number of Seedlings.						
			Deep (d)	Medium (m)	Pale (p)	None (o)	Flush only (f)	Stripes only (s)	Flush and Stripes (fs)
Allington Pippin	× Red Astrachan ..	p,fs : d,f	1	5	3	–	4	–	5
,, ,,	× Star of Devon ..	p,fs : d,fs	3	10	5	1	9	–	9
,, ,,	× Worcester ..	p,fs : d,f	5	19	6	–	14	1	16
,, ,,	open-pollinated ..	p,fs :	31	31	2	–	39	3	27
American Mother	× Cox's Orange ..	d,fs : m,fs	4	4	–	–	5	–	3
Bismarck	× Hollandbury ..	d,fs : m,f	2	8	4	–	7	–	7
,,	× Jonathan	d,fs : d,fs	2	8	2	–	7	–	5
,,	open-pollinated ..	d,fs :	5	34	8	1	34	–	13
Cap of Liberty	× M3E	d,fs : m,fs	–	9	7	1	13	–	3
Court Pendu	× Cox's Orange ..	d,f : m,fs	5	8	2	1	11	–	4
,, ,,	× Dabinett	d,f : d,fs	1	6	2	1	3	–	6
,, ,,	× Sweet Alford ..	d,f : p,f	–	11	3	6	10	–	4
,, ,,	× Wellington ..	d,f : m,f	5	21	8	2	25	–	9
Cox's Orange	× Beauty of Bath ..	m,fs : m,fs	–	4	1	1	4	1	1
,, ,,	× Reinette Obry ..	m,fs : o,o	–	4	4	4	5	1	3
,, ,,	× Wealthy	m,fs : d,fs	3	13	1	–	12	–	5
,, ,,	open-pollinated ..	m,fs :	3	112	4	–	80	1	36
Devon Quarrenden	× Cox's Orange ..	d,f : m,fs	11	11	4	3	23	–	3
Gascoyne's S.	× Wellington ..	d,fs : m,f	1	6	4	–	7	–	4
Lord Derby	open-pollinated ..	o,o :	–	–	3	11	3	–	–
Medaille d'Or	× Kingston Black ..	p,f : d,fs	1	21	4	–	9	2	17
Newton Wonder	× Lord Derby ..	m,fs : o,o	–	1	3	1	–	1	3
,, ,,	× Morgan Sweet ..	m,fs : o,o	–	12	1	–	7	–	6
Stirling Castle	× Morgan Sweet ..	p,f : o,o	–	9	24	17	27	3	6
Sturmer Pippin	× Sweet Alford ..	m,f : p,f	–	5	8	1	13	–	–
Wealthy	× Sweet Alford ..	d,fs : p,f	7	45	18	–	36	3	35
,,	open-pollinated ..	d,fs :	1	10	5	–	3	2	11
Wellington	× Ecklinville ..	m,f : p,f	–	4	11	4	15	–	–
,,	× Lord Derby ..	m,f : o,o	–	–	6	3	6	–	–
Worcester	× Beauty of Bath ..	d,f : m,fs	8	11	3	–	10	4	8
,,	open-pollinated ..	d,f :	5	9	2	–	3	2	11

TABLE V.

Ground Colour and Russet of Fruit Skin.

Parents.		*Ground Colour and Russet of Parents.*	*Number of Seedlings.*						
			Dark Yellow (d)	*Pale Yellow* (p)	*White* (w)	*Green* (g)	*Much Russet* (r)	*Slight Russet* (s)	*No. Russet* (o)
Allington Pippin	× Red Astrachan ..	p,o : p,o	2	7	–	–	–	–	9
,, ,,	× Star of Devon ..	p,o : d,o	7	8	1	–	–	3	16
,, ,,	× Worcester ..	p,o : d,o	9	14	–	–	–	13	17
,, ,,	open-pollinated ..	p,o :	7	11	–	40	4	12	57
American Mother	× Cox's Orange ..	d,o : p,s	1	2	–	1	–	2	6
Bismarck	× Hollandbury ..	p,o : p,o	–	8	1	2	–	–	14
,,	× Jonathan ..	p,o : p,o	–	3	1	6	–	4	8
,,	open-pollinated ..	p,o :	1*	16*	*	*	–	16	33
Cap of Liberty	× M3E	p,s : p,r	2	7	–	–	7	7	3
Court Pendu	× Cox's Orange ..	d,r : p,s	5	4	–	6	4	5	7
,, ,,	× Dabinett	d,r : p,s	*	2*	*	2*	–	–	10
,, ,,	× Sweet Alford ..	d,r : w,o	3	16	–	1	–	1	20
,, ,,	× Wellington ..	d,r : p,o	14	10	–	3	8	7	20
Cox's Orange	× Beauty of Bath ..	p,s : p,s	2	5	–	–	–	1	6
,, ,,	× Reinette Obry ..	p,s : p,s	6	7	–	1	–	2	11
,, ,,	× Wealthy	p,s : p,o	4	9	–	2	–	1	14
,, ,,	open-pollinated ..	p,s :	14	11	–	74	2*	8*	60*
Devon Quarrenden	× Cox's Orange ..	d,o : p,s	7	16	–	3	1	7	21
Gascoyne's S.	× Wellington ..	p,o : p,o	–	5	–	4	–	1	10
Lord Derby	open-pollinated ..	p,o :	–	9	1	4	–	2	12
Medaille d'Or	× Kingston Black ..	d,r : d,r	13	13	–	2	5	15	8
Newton Wonder	× Lord Derby ..	d,o p,o	–	3	–	1	–	1	4
,, ,,	× Morgan Sweet ..	d,o p,o	1	10	–	2	–	1	12
Stirling Castle	× Morgan Sweet ..	p,s : p,o	–	31	1	13	1	6	46
Sturmer Pippin	× Sweet Alford ..	d,s : w,o	1	11	–	–	1	3	10
Wealthy	× Sweet Alford ..	p,o : w,o	5	47	–	10	–	7	67
,,	open-pollinated ..	p,o :	2	11	1	2	–	2	14
Wellington	× Ecklinville ..	p,o : p,o	–	9	–	10	–	1	18
,,	× Lord Derby ..	p,o : p,o	–	8	–	1	–	1	8
Worcester	× Beauty of Bath ..	d,o : p,s	9	11	–	–	–	3	18
,,	open-pollinated ..	d,o :	2	3	–	–	–	1	12

* Data incomplete.

TABLE VI.

FLESH CHARACTERS OF FRUIT.

Parents.		Flesh Characters of Parents.	Number of Seedlings.									
			Yellow (y)	Cream (c)	White (w)	Greenish (gr)	Crisp (cr)	Tough (t)	Soft (s)	Juice Good (g)	Juice Medium (m)	Juice Poor (p)
Allington Pippin	× Red Astrachan ..	c,cr,g : w,cr,g	–	7	2	–	8	1	–	1	8	–
,, ,,	× Star of Devon ..	c,cr,g : w,s,m	4	8	7	–	13	3	–	2	11	4
,, ,,	× Worcester ..	c,cr,g : c,s,m	6	20	4	–	17	13	–	4	17	9
,, ,,	open-pollinated ..	c,cr,g :	13	36	16	9	35	32	6	4	48	22
American Mother	× Cox's Orange ..	c,s,g : y,cr,g	4	4	–	–	6	2	–	2	4	2
Bismarck	× Hollandbury ..	gr,cr,g : w,s,m	–	3	10	1	9	4	1	2	7	5
,,	× Jonathan ..	gr,cr,g : c,cr,g	1	1	2	8	8	2	2	1	8	3
,,	open-pollinated ..	gr,cr,g :	–	14	22	13	38	5	5	1	34	13
Cap of Liberty	× M3E	c,cr,m : c,s,p	4	13	1	–	8	10	–	–	9	9
Court Pendu	× Cox's Orange ..	y,t,m : y,cr,g	8	6	1	1	5	11	–	1	9	6
,, ,,	× Dabinett ..	y,t,m : w,t,m	4	2	1	3	6	3	1	1	4	5
,, ,,	× Sweet Alford ..	y,t,m : c,t,m	2	15	1	3	14	7	–	–	17	4
,, ,,	× Wellington ..	y,t,m : w,cr,g	18	15	–	2	18	16	1	1	16	18
Cox's Orange	× Beauty of Bath ..	y,cr,g : w,cr,m	3	4	–	–	3	4	–	1	5	1
,, ,,	× Reinette Obry ..	y,cr,g : c,cr,g	3	10	–	–	8	3	2	–	10	3
,, ,,	× Wealthy ..	y,cr,g : w,s,g	1	10	4	–	8	3	4	4	9	2
,, ,,	open-pollinated ..	y,cr,g :	8	72	17	13	83	23	17	12	86	23
Devon Quarrenden	× Cox's Orange ..	gr,cr,g : y,cr,g	5	22	2	–	25	4	–	4	23	2
Gascoyne's S.	× Wellington ..	w,s,m : w,cr,g	–	3	6	2	7	2	2	3	7	1
Lord Derby	open-pollinated ..	c,s,m :	–	7	7	–	7	4	3	1	7	6
Medaille d'Or	× Kingston Black ..	c,s,g : w,s,m	1	7	14	5	14	10	4	9	8	8
Newton Wonder	× Lord Derby ..	y,cr,g : c,s,m	–	2	3	2	4	1	–	–	4	1
,, ,,	× Morgan Sweet ..	y,cr,g : w,s,m	1	11	1	–	9	4	–	–	6	7
Stirling Castle	× Morgan Sweet ..	w,s,m : w,s,m	1	29	21	4	30	16	7	2	28	22
Sturmer Pippin	× Sweet Alford ..	w,cr,g : c,t,m	2	9	3	–	9	4	1	–	12	2
Wealthy	× Sweet Alford ..	w,s,g : c,t,m	2	51	13	5	53	5	13	10	49	11
,,	open-pollinated ..	w,s,g :	–	7	5	4	13	1	2	3	11	2
Wellington	× Ecklinville ..	w,cr,g : w,cr,g	–	8	10	1	12	1	6	7	10	2
,,	× Lord Derby ..	w,cr,g : c,s,m	–	7	1	1	6	3	–	2	7	–
Worcester	× Beauty of Bath ..	c,s,m : w,cr,m	–	18	1	–	14	3	–	2	12	3
,,	open-pollinated ..	c,s,m :	–	9	1	5	9	6	–	–	8	6

TABLE VII.

Sweetness, Acidity and Aroma of Fruit.

Parents.		*Sugar, Acid and Aroma of Parents.*	*Number of Seedlings.*								
			Sugar.			*Acid.*			*Aroma.*		
			Good (g)	*Medium* (m)	*Poor* (p)	*Good* (g)	*Medium* (m)	*Poor* (p)	*Good* (g)	*Medium* (m)	*Poor* (p)
Allington Pippin	× Red Astrachan	g,g,g : g,m,m	1	8	–	1	8	–	–	9	–
,, ,,	× Star of Devon	g,g,g : m,m,m	4	11	1	3	9	4	3	8	5
,, ,,	× Worcester	g,g,g : g,m,m	15	14	–	3	18	8	1	17	11
,, ,,	open-pollinated	g,g,g :	13	45	13	5	54	12	2	23	47
American Mother	× Cox's Orange	g,m,g : g,m,g	6	2	–	5	3	–	3	4	1
Bismarck	× Hollandbury	m,g,p : m,g,p	1	10	3	10	4	–	–	2	12
,,	× Jonathan	m,g,p : g,m,g	4	8	–	1	11	–	1	7	4
,,	open-pollinated	m,g,p :	3	31	15	22	23	4	–	8	41
Cap of Liberty	× M3E	m,g,p : g,p,m	–	11	7	8	12	–	–	–	15
Court Pendu	× Cox's Orange	g,m,g : g,m,g	7	8	–	1	11	3	3	10	2
,, ,,	× Dabinett	g,m,g : g,p,p	2	7	1	3	5	2	–	1	9
,, ,,	× Sweet Alford	g,m,g : g,p,p	6	14	1	5	12	4	–	9	12
,, ,,	× Wellington	g,m,g : p,g,p	6	25	4	5	27	3	5	16	14
Cox's Orange	× Beauty of Bath	g,m,g : g,m,g	3	1	2	2	4	–	2	2	2
,, ,,	× Reinette Obry	g,m,g : p,g,m	4	9	–	2	7	5	–	5	8
,, ,,	× Wealthy	g,m,g : g,m,m	8	6	1	1	9	5	2	10	3
,, ,,	open-pollinated	g,m,g :	30	90	6	2	113	6	19	43	65
Devon Quarrenden	× Cox's Orange	g,g,m : g,m,g	13	12	2	1	16	10	4	17	6
Gascoyne's S.	× Wellington	m,g,p : p,g,p	–	8	3	4	7	–	–	3	8
Lord Derby	open-pollinated	p,m,p :	2	7	5	4	8	2	–	–	14
Medaille d'Or	× Kingston Black	g,p,p : m,m,p	11	15	2	8	11	8	–	2	26
Newton Wonder	× Lord Derby	m,m,m : p,m,p	–	3	2	1	3	1	–	–	5
,, ,,	× Morgan Sweet	m,m,m : m,p,p	5	8	–	–	9	5	–	3	9
Stirling Castle	× Morgan Sweet	p,g,p : m,p,p	15	27	12	11	24	18	–	5	47
Sturmer Pippin	× Sweet Alford	g,m,g : g,p,p	–	12	2	7	7	–	–	4	10
Wealthy	× Sweet Alford	g,m,m : g,p,p	12	56	6	23	40	9	1	36	35
,,	open-pollinated	g,m,m :	6	10	–	3	10	2	2	9	4
Wellington	× Ecklinville	p,g,p : p,g,p	1	11	7	15	4	–	–	4	15
,,	× Lord Derby	p,g,p : p,m,p	–	5	4	8	1	–	–	–	9
Worcester	× Beauty of Bath	g,m,m : g,m,g	14	2	–	7	8	–	2	12	1
,,	open-pollinated	g,m,m :	3	9	2	1	13	–	–	7	7

TABLE VIII.
SEASON OF FRUITS.

Parents.		*Seasons of Parents.*	*Number of Seedlings.*							
			Aug.	*Early Sept.*	*Late Sept.*	*Early Oct.*	*Late Oct.*	*Nov.*	*Dec.*	*Jan.*—
Allington Pippin	× Red Astrachan ..	Dec. : Aug.	1	1	4	1	1	1	–	–
,, ,,	× Star of Devon ..	Dec. : Jan.	2	3	4	3	6	1	–	–
,, ,,	× Worcester ..	Dec. : L. Sept.	–	1	8	10	9	4	–	–
,, ,,	open-pollinated ..	Dec. :	2	2	13	10	17	21	3	3
American Mother	× Cox's Orange ..	Nov. : Dec.	–	–	1	3	2	2	–	–
Bismarck	× Hollandbury ..	Dec. : Nov.	–	1	2	2	7	2	–	–
,,	× Jonathan ..	Dec. : Nov.	–	–	1	–	3	7	1	–
,,	open-pollinated ..	Dec. :	–	–	4	4	21	17	–	–
Cap of Liberty	× M3E	Nov. : L. Oct.	–	–	3	5	4	4	–	–
Court Pendu	× Cox's Orange ..	Feb. : Dec.	–	–	–	–	4	7	3	2
,, ,,	× Dabinett ..	Feb. : Nov.	–	–	1	–	4	5	–	–
,, ,,	× Sweet Alford ..	Feb. : L. Oct.	–	–	–	2	10	5	2	–
,, ,,	× Wellington ..	Feb. : Feb.	–	–	–	–	15	10	7	3
Cox's Orange	× Beauty of Bath ..	Dec. : Aug.	–	1	3	2	1	1	–	–
,, ,,	× Reinette Obry ..	Dec. : Jan.	–	–	1	1	4	6	1	–
,, ,,	× Wealthy ..	Dec. : L. Oct.	–	–	2	8	3	3	1	–
,, ,,	open-pollinated ..	Dec. :	4	21	28	26	20	20	5	4
Devon Quarrenden	× Cox's Orange ..	E. Sept. : Dec.	–	–	19	6	4	–	–	–
Gascoyne's S.	× Wellington ..	Nov. : Feb.	–	–	–	3	3	4	1	–
Lord Derby	open-pollinated ..	Nov. :	–	4	3	5	1	1	–	–
Medaille d'Or	× Kingston Black ..	Dec. : Dec.	–	–	–	4	19	2	–	–
Newton Wonder	× Lord Derby ..	Dec. : Nov.	–	–	–	2	1	2	–	–
,, ,,	× Morgan Sweet ..	Dec. : L. Sept.	–	–	2	4	5	2	–	–
Stirling Castle	× Morgan Sweet ..	L. Sept. : L. Sept.	–	3	12	15	18	5	–	–
Sturmer Pippin	× Sweet Alford ..	Mar. : L. Oct.	–	–	–	–	5	3	4	2
Wealthy	× Sweet Alford ..	L. Oct. : L. Oct.	–	–	18	25	24	6	1	–
,,	open-pollinated ..	L. Oct. :	2	8	4	2	–	–	–	–
Wellington	× Ecklinville ..	Feb. : E. Oct.	–	–	3	6	6	4	–	–
,,	× Lord Derby ..	Feb. : Nov.	–	–	1	–	3	3	1	1
Worcester	× Beauty of Bath ..	L. Sept. : Aug.	9	8	3	1	–	–	–	–
,,	open-pollinated ..	L. Sept. :	–	2	1	2	6	3	–	–

TABLE IX.
USE OF FRUITS.

Parents.		Use of Parents.	Number of Seedlings.			
			Culinary.	*Dessert.*	*Cider.*	*Useless.*
Allington Pippin	× Red Astrachan	D : D	–	8	–	1
,, ,,	× Star of Devon	D : D	1	8	–	7
,, ,,	× Worcester	D : D	1	19	3	6
,, ,,	open-pollinated	D :	16	11	2	47
American Mother	× Cox's Orange	D : D	–	7	–	1
Bismarck	× Hollandbury	C : C	13	1	–	–
,,	× Jonathan	C : D	5	4	–	3
,,	open-pollinated	C :	43	4	–	5
Cap of Liberty	× M3E	Cid. : Cid.	–	–	12	8
Court Pendu	× Cox's Orange	D : D	–	10	–	5
,, ,,	× Dabinett	D : Cid.	2	1	–	6
,, ,,	× Sweet Alford	D : Cid.	3	–	–	18
,, ,,	× Wellington	D : C	–	18	–	17
Cox's Orange	× Beauty of Bath	D : D	–	4	–	3
,, ,,	× Reinette Obry	D : Cid.	–	3	–	10
,, ,,	× Wealthy	D : D	1	11	–	2
,, ,,	open-pollinated	D :	22	46	–	61
Devon Quarrenden	× Cox's Orange	D : D	1	22	–	5
Gascoyne's S.	× Wellington	D : C	4	–	–	7
Lord Derby	open-pollinated	C :	14	–	–	–
Medaille d'Or	× Kingston Black	Cid. : Cid.	–	–	26	–
Newton Wonder	× Lord Derby	C : C	2	–	–	3
,, ,,	× Morgan Sweet	C : Cid.	–	–	–	11
Stirling Castle	× Morgan Sweet	C : Cid.	19	2	1	31
Sturmer Pippin	× Sweet Alford	D : Cid.	5	3	–	6
Wealthy	× Sweet Alford	D : Cid.	13	17	2	39
,,	open-pollinated	D :	3	9	–	4
Wellington	× Ecklinville	C : C	18	1	–	–
,,	× Lord Derby	C : C	8	–	–	1
Worcester	× Beauty of Bath	D : D	–	15	–	–
,,	open-pollinated	D :	1	9	–	5

TABLE X.
Blossom Date.

Parents.		Blossom Dates of Parents.	Number of Seedlings. Early (E)	Medium Early (ME)	Medium Late (ML)	Late (L)	Very Late (VL)
Allington Pippin	× Red Astrachan	ME : E	3	3	4	1	–
,, ,,	× Star of Devon	ME : ME	3	11	6	1	–
,, ,,	× Worcester	ME : ML	3	8	19	–	–
,, ,,	open-pollinated	ME :	2	34	35	6	–
American Mother	× Cox's Orange	L : ME	–	–	2	7	–
Bismarck	× Hollandbury	E : L	2	3	6	–	–
,,	× Jonathan	E : ?	–	7	5	–	–
,,	open-pollinated	E :	7	27	20	2	–
Cap of Liberty	× M3E	ME : VL	–	–	5	11	6
Court Pendu	× Cox's Orange	VL : ME	–	–	6	5	7
,, ,,	× Dabinett	VL : L	–	–	1	4	5
,, ,,	× Sweet Alford	VL : ML	–	–	3	11	12
,, ,,	× Wellington	VL : L	–	–	8	16	17
Cox's Orange	× Beauty of Bath ..	ME : E	–	2	5	2	–
,, ,,	× Reinette Obry	ME : L	–	–	7	6	1
,, ,,	× Wealthy	ME : ME	–	–	22	1	–
,, ,,	open-pollinated	ME :	4	31	79	15	2
Devon Quarrenden	× Cox's Orange	E : ME	1	4	28	4	–
Gascoyne's S.	× Wellington	L : L	–	–	7	5	–
Lord Derby	open-pollinated	ML :	2	4	8	–	–
Medaille d'Or	× Kingston Black ..	VL : ML	–	–	3	8	4
Newton Wonder	× Lord Derby	L : ML	–	–	5	–	–
,, ,,	× Morgan Sweet	L : ML	–	–	4	10	–
Stirling Castle	× Morgan Sweet	E : ML	1	8	38	11	–
Sturmer Pippin	× Sweet Alford	ME : ML	1	1	6	7	–
Wealthy	× Sweet Alford	ME : ML	–	2	46	41	3
,,	open-pollinated	ME :	1	6	9	–	–
Wellington	× Ecklinville	L : ML	–	5	10	8	–
,,	× Lord Derby	L : ML	–	–	1	9	–
Worcester	× Beauty of Bath ..	ML : E	2	14	17	3	–
,,	open-pollinated	ML :	–	1	8	5	1

TABLE XI.

Tree Size and Habit.

Parents.		Size and Habit of Parents.	Number of Seedlings.					
			Large (l)	Medium (m)	Small (s)	Erect (e)	Medium (m)	Spreading (s)
Allington Pippin	× Red Astrachan	l,s : m,m	5	6	1	2	8	2
,, ,,	× Star of Devon	l,s : m,m	10	8	2	3	6	11
,, ,,	× Worcester	l,s : m,m	27	2	1	13	8	9
,, ,,	open-pollinated	l,s :	21	43	25	14	45	30
American Mother	× Cox's Orange	m,m : m,m	4	4	1	4	4	1
Bismarck	× Hollandbury	m,s : m,m	5	5	1	3	7	1
,,	× Jonathan	m,s : m,m	4	6	2	–	4	8
,,	open-pollinated	m,s :	14	28	13	12	23	22
Cap of Liberty	× M3E	l,e : m,m	10	11	1	7	13	2
Court Pendu	× Cox's Orange	s,e : m,m	10	6	2	8	5	6
,, ,,	× Dabinett	s,e : m,m	6	4	–	2	5	3
,, ,,	× Sweet Alford	s,e : l,s	1	17	7	6	13	6
,, ,,	× Wellington	s,e : l,m	24	11	7	29	9	4
Cox's Orange	× Beauty of Bath	m,m : l,s	4	4	10	5	5	8
,, ,,	× Reinette Obry	m,m : m,m	6	6	3	11	3	1
,, ,,	× Wealthy	m,m : l,s	4	9	3	9	6	1
,, ,,	open-pollinated	m,m :	55	70	19	44	84	16
Devon Quarrenden	× Cox's Orange	m,s : m,m	17	14	6	14	14	9
Gascoyne's S.	× Wellington	l,s : l,m	5	4	3	–	6	6
Lord Derby	open-pollinated	l,e :	9	5	–	8	4	2
Medaille d'Or	× Kingston Black	m,s : l,s	15	9	3	7	11	9
Newton Wonder	× Lord Derby	l,s : l,e	4	1	–	2	1	2
,, ,,	× Morgan Sweet	l,s : l,e	9	3	2	9	4	1
Stirling Castle	× Morgan Sweet	s,m : l,e	15	27	14	15	31	11
Sturmer Pippin	× Sweet Alford	m,m : l,s	2	12	1	5	7	2
Wealthy	× Sweet Alford	l,s : l,s	34	43	25	34	55	8
,,	open-pollinated	l,s :	9	7	2	9	6	3
Wellington	× Ecklinville	l,m : l,m	9	10	5	4	8	12
,,	× Lord Derby	l,m : l,e	2	4	5	5	3	3
Worcester	× Beauty of Bath	m,m : l,s	27	2	1	13	8	9
,,	open-pollinated	m,m :	4	12	2	6	9	3

TABLE XII.

Susceptibility to Mildew, Scab and Canker.

Parents.	Susceptibility of Parents.*	Number of Seedlings.											
		Mildew.				*Scab.*				*Canker.*			
		Bad	*Medium*	*Slight*	*None*	*Bad*	*Medium*	*Slight*	*None*	*Bad*	*Medium*	*Slight*	*None*
Allington Pippin × Red Astrachan ..	Ms : msc	3	7	2	–	–	8	–	1	–	1	–	11
,, ,, × Star of Devon ..	Ms : msc	5	12	4	–	2	9	3	5	–	–	–	21
,, ,, × Worcester ..	Ms : mSc	–	7	20	4	1	8	9	13	1	–	–	30
,, ,, open-pollinated ..	Ms :	10	45	18	15	1	13	9	65	–	2	–	86
American Mother × Cox's Orange ..	msc : MSC	1	4	4	–	–	2	2	4	–	–	–	9
Bismarck × Hollandbury ..	MSc : msc	1	3	6	1	2	1	1	7	–	2	–	9
,, × Jonathan ..	MSc : msc	4	5	2	1	1	4	2	5	–	–	–	12
,, open-pollinated ..	MSc :	13	30	8	5	2	14	5	27	–	1	2	55
Cap of Liberty × M3E	SC : msc	2	6	3	12	1	–	5	15	–	–	–	23
Court Pendu × Cox's Orange ..	msc : MSC	2	4	6	6	3	3	3	9	1	5	–	12
,, ,, × Dabinett ..	msc : mc	–	1	3	6	–	3	–	7	–	–	1	9
,, ,, × Sweet Alford ..	msc : mSc	–	3	16	5	–	1	–	21	–	1	–	24
,, ,, × Wellington ..	msc : MSc	5	25	11	2	2	18	5	13	6	22	2	13
Cox's Orange × Beauty of Bath ..	MSC : msc	–	2	6	–	–	1	1	4	–	–	–	8
,, ,, × Reinette Obry ..	MSC : msc	1	7	6	1	1	4	4	4	–	–	–	15
,, ,, × Wealthy ..	MSC : msc	1	10	21	2	3	3	3	8	–	3	–	30
,, ,, open-pollinated ..	MSC :	7	85	21	30	7	31	10	95	2	14	1	125
Devon Quarrenden × Cox's Orange ..	mSc : MSC	4	20	11	3	4	12	11	5	–	1	–	36
Gascoyne's S. × Wellington ..	msc : msc	–	1	8	3	1	1	1	8	1	–	–	11
Lord Derby open-pollinated ..	msc :	1	3	9	1	–	2	4	8	4	2	–	8
Medaille d'Or × Kingston Black ..	msc : msC	2	5	6	10	–	–	–	23 ?	1	5	7	10
Newton Wonder × Lord Derby ..	msc : msc	–	2	2	1	–	1	1	3	–	–	–	5
,, ,, × Morgan Sweet ..	msc : msc	2	8	4	1	–	2	3	8	–	–	–	15
Stirling Castle × Morgan Sweet ..	MSC : msc	7	17	21	17	4	3	6	39	–	1	2	57
Sturmer Pippin × Sweet Alford ..	msC : mSc	1	4	7	2	–	–	2	12	–	–	–	14
Wealthy × Sweet Alford ..	msc : mSc	2	28	46	21	1	3	7	62	–	2	–	100
,, open-pollinated ..	msc :	–	6	8	3	–	–	4	12	–	1	1	15
Wellington × Ecklinville ..	MSC : mSC	8	5	7	4	1	2	1	14	–	1	–	23
,, × Lord Derby ..	MSC : msc	3	5	1	–	1	2	1	3	–	–	–	11
Worcester × Beauty of Bath ..	mSc : msc	–	4	14	23	–	–	6	35	2	9	1	29
,, open-pollinated ..	mSc :	–	1	7	7	–	1	3	11	3	2	–	10

* Parents very susceptible to Mildew, Scab and Canker indicated by M, S, C, respectively.
Parents moderately suceptible to Mildew, Scab and Canker indicated by m, s, c, respectively.
Parents very slightly susceptible to Mildew, Scab and Canker indicated by absence of a symbol.

TABLE XIII.

Number of Seedlings Selected for Propagation and Further Trial.

Parents.		*Use of Parents.*	*Number of Seedlings.*		
			Dessert (D)	*Culinary* (C)	*Cider* (Cid.)
Allington Pippin	× Cox's Orange	D : D	1	–	–
,, ,,	× Red Astrachan	D : D	1	–	–
,, ,,	× Star of Devon	D : D	3	–	–
,, ,,	× Worcester	D : D	1	–	1
,, ,,	open-pollinated	D :	–	2	1
American Mother	× Cox's Orange	D : D	2	–	–
Bismarck	open-pollinated	C :	–	1	–
Beauty of Bath	open-pollinated	D :	1	–	–
Court Pendu	× Cox's Orange	D : D	1	–	–
Cox's Orange	× Beauty of Bath	D : D	2	–	–
,, ,,	× Lady Sudeley	D : D	1	–	–
,, ,,	× Sturmer Pippin	D : D	1	–	–
,, ,,	× Wealthy	D : D	2	–	–
,, ,,	open-pollinated	D :	3	–	–
Devon Quarrenden	× Cox's Orange	D : D	3	–	–
Frogmore Prolific	open-pollinated	C :	–	3	–
James Grieve	open-pollinated	D :	1	–	–
Lord Derby	× Bismarck	C : C	–	1	–
,, ,,	open-pollinated	C :	–	3	–
Red Astrachan	× Jonathan	D : D	1	–	
Wealthy	open-pollinated	D :	1	1	

INVESTIGATIONS ON THE VARIABILITY OF APPLE TREES ON SEEDLING AND ON CLONE ROOT-STOCKS.

PROGRESS REPORT.—I.

By G. T. SPINKS.

INTRODUCTION.

It is now well established that certain clone root-stocks when worked with a scion variety of apple by budding or grafting a few inches above the ground level will, in general, produce characteristic effects on the growth of the scion. There is, also, fairly general agreement that, if it is desired to restrict the growth of trees and to ensure that they will come into bearing at an early age, these objects can be achieved by the use of certain clone root-stocks which are known to produce the desired effects. If, however, the object in view is the growing of large permanent trees, and early cropping is not of importance, as in many orchards of standard trees, the necessity for using clone root-stocks is not equally well established. In such cases seedling stocks have been almost universally used in the past and are still very commonly used at the present time. It is claimed for the clone stock that its use eliminates the unknown factor of the influence of different seedling roots and that it produces a much more uniform set of trees. On the other hand, rows of very uniform mature trees worked on seedling stocks are sometimes shown as evidence that uniformity of performance can be obtained on those stocks.

The amount of reliable data on these points is very small. The past history of the trees on seedling stocks is often incompletely known, as no continuous records of crops have been kept, and the occurrence of scion-rooting of the trees and also of any comparable trees on clone stocks is often in doubt.

From observations on mature trees Sax and Gowan (4, 5) conclude that seedling stocks produce variable results. Hatton (2) suggests that the uniformity of standard trees in grass orchards, where it exists, is due to rigorous grading of the trees when transplanting from the nursery, and states that his own observations in commercial nurseries confirm this view, but he gives no figures. In the same paper, Hatton cites observations made at East Malling on several series of trees ranging in age from one year to fourteen years which show that the trees on seedling stocks are significantly more variable than those on clone stocks. From measurements of one and two-year-old trees worked on various clone stocks and on seedling stocks from different sources, Anthony and Yerkes (1) conclude that in the majority of cases the seedling stocks gave more variable results. Hatton also quotes Roberts, who found that "Doucin" stocks produced slightly more uniform trees than seedling stocks (3).

The above appear to be the only available records of definite observations on the relative variability of trees on the two classes of root-stock, and it was in order to obtain further data on this point that the following trials were begun at Long Ashton some years ago.

EXPERIMENTAL.

Plan of the Investigation.

In carrying out these trials it was proposed :—

(1) To grow seedlings from
    (*a*) mixed seed of unknown origin,
    (*b*) seed from several separate varieties of "Crab."

(2) To grade the seedlings according to size and root characters when they were transplanted from the seed bed to the nursery rows.

(3) To work each set of seedlings with a single scion variety and to grow the trees as full standards.

(4) To make observations on the growth and performance of as many trees as possible on the different varieties and grades of seedlings from the maiden stage onwards to maturity.

(5) To compare the variability of trees on the seedling stocks with that of comparable trees on clone stocks.

(6) To find whether the use of graded seedlings and seedlings from single varieties affected the variability of the trees.

Material Used and Observations Made.

The above plan is being carried out and the following series of seedling stocks were worked between 1925 and 1930 :—

(1) Mixed seedlings : origin unknown.

(2) "Hampshire Crab." This seed was obtained from certain wild apple trees from which a Hampshire nurseryman always obtains his seed for "crab" stocks.

(3) "Wootton's Crab." This is a particular "crab" which is used by Mr. J. H. Wootton, of Byford, Herefordshire, for the production of stocks.

(4) "New Forest Crab." The seed was supplied to us by the East Malling Research Station and was obtained from wild trees in the New Forest.

(5) "*Malus acerba*." This seed came from very old wild apple trees in Ireland and was sent to us by the late Prof. A. Henry, who stated that he believed the trees to represent the original species of apple indigenous in Ireland.

In each case the seedlings were grown for two years in the seed bed and were then transplanted to nursery rows. At the time of transplanting the seedlings were graded according to the type of root system present and also according to size.

The plants were divided into groups in which the following different types of root systems were present :—

A. Single tap-root, very few fibres.
B. ,, ,, ,, moderate fibre or fine laterals.
C. Tap-root divided or with strong laterals, very few fibres.
D. ,, ,, ,, ,, ,, ,, ,, moderate fibre.

The plants within each group were graded for size by measuring the length of the shoot, as follows :—

a. Shoot length over 50 cm.
b. ,, ,, 50—40 cm.
c. ,, ,, 40—30 cm.
d. ,, ,, 30—20 cm.
e. ,, ,, under 20 cm.

The seedlings were thus finally graded in a number of sub-groups. *e.g.* Aa, Ab, Ba, and so on.

The first four sets of stocks were worked with Bramley's Seedling, and the last with Newton Wonder. Propagation was carried out by budding in the usual way, though in some cases buds failed and it was necessary to graft in the following year. The resulting trees were run up to form full standards, being headed at a height of just over 6ft.

While the trees were in the nursery various measurements were made, such as the shoot growths in the first and second years, but the chief measurement taken has been the diameter of the main stem, 1ft. above the union, taken at various ages. From the present age of the trees, it will be seen that most of the records up to date deal with trees in the nursery stage. When the trees were moved to their permanent quarters, at the age of 4 or 5 years, they were all weighed but their weight is that of the tree after a considerable quantity of roots had been severed in the process of lifting the trees ; a small amount of soil was also adhering to the roots, though as much as possible was removed.

Since the trees were planted in their permanent positions, other records, such as height, spread of branches, number of flower trusses and number and weight of fruits, have been taken. The oldest trees, however, have borne only one crop, while the youngest trees have but recently been planted out, so that the data obtained from trees in their post-nursery stage are at present only scanty.

For comparison with the above sets of seedling stocks, various batches of trees on clone stocks have also been the subject of measurement from time to time. In some cases the trees on the two kinds of stock were growing in the same section of nursery, were worked at the same time with the same scion variety, and are therefore strictly comparable. Trees of the scion varieties Worcester Pearmain and Bramley's Seedling, though worked in different years, were also measured in order to obtain additional data on the amount of variation found in trees on clone stocks.

In the following accounts of the various series of trees which were grown, it will be noticed that in some cases trees were produced from only about half the stocks which had been planted. This, however, cannot be attributed to any disability specially associated with seedling stocks, for an equally small percentage of trees was produced from the various clone stocks planted at the same time. Many stocks died during the first year and on some of the remainder the buds or grafts failed to take. The death of such a large number of young stocks is thought to be due to unfavourable weather after planting, combined with unsuitable soil conditions. The soil varied in different parts of the nursery and in some places was liable to be waterlogged. A large proportion of the bud failures was caused by attacks of the Red Bud Borer Midge. It is evident that the conditions in the nursery were not those most favourable to the production of uniform trees, but the conditions were the same for both seedling and clone stocks.

It should be emphasised that the nursery data to be considered were taken from almost every tree in the nursery rows and not only from selected samples. The few trees omitted from the measurements were those which had suffered from accidental or external causes unconnected with the root-stocks. Such trees were found on both clone and seedling stocks. When trial plots were planted no attempt was made to pick out a uniform sample of the trees on seedling stocks, but, with the above exceptions, every tree on each series of seedlings was used in order to test the variability of the whole batch of seedlings. As some of the trial plots were also designed to compare one clone stock with another, the trees on clone stocks were usually more carefully selected to provide a uniform sample. This procedure may have given the clone stocks in the trials an initial advantage over the seedling stocks as regards the uniformity of the material used.

Mixed Seedlings. In February, 1924, about 140 two-year-old apple seedlings of unknown origin were planted in the nursery, after being graded as described above. The plants were very well-grown, so that even the smallest of them were included in grade " A," and some had stems as much as 120 cm. in length. There were considerable differences in the character of the shoot growth, the most noticeable being in the number of spines. The stocks were not budded with Bramley's Seedling until 1925. A number of stocks died and in many cases the bud or graft did not take, with the result that the number of maiden plants obtained was 69. Of these several received injuries and several more had made very poor unions owing to the large size of the stock when worked, and it seemed that these might legitimately be ignored when taking records. 51 trees were eventually planted out as standards in one plantation when three years old, but two years later various mishaps had reduced this number to 44.

Hampshire Crab. Several hundred two-year-old seedlings were planted in the nursery, after grading, in January 1924. These experienced the same conditions as the Mixed Seedlings, were not budded until 1925 and maidens were obtained on only about 50% of the stocks. The majority of the stocks were included in group " D," having divided roots with a moderate amount of fibre, while there were very few plants in groups " A " and " C " (few fibres). Although it may be accidental it is perhaps worth noting that very few of the " A " and " C " plants survived to produce maidens. There appeared to be no correlation between the vigour of stocks at the time of budding and the original size of the seedlings when planted. Although there were a small number of exceptions, the great majority of the seedlings of this " crab " appeared to be very uniform in their stem and leaf characters.

The scion variety was again Bramley's Seedling and the trees were run up to form full standards. All trees which could be regarded as having had a fair start were measured from time to time and as many as possible were planted in trial plots as follows :—

(1) 20 trees in cultivated plantation at Long Ashton. Trees on layered stocks also planted in this plot.

(2) 62 trees in grass at Rodley, Gloucestershire.

(3) 50 trees in grass at Standish, Gloucestershire. Trees on layered stocks also planted in this plot.

The subsequent history of the grass plots emphasised some of the difficulties of carrying out trials of this nature. Some trees died owing to bad drainage conditions in the soil, though this had not been detected before planting. Other trees suffered very badly from the same cause, though they were not actually killed, and if such trees are included in a statistical record the differences found may give a misleading idea of their inherent variability.

In taking trees from the nursery for the above and similar trials the selection of the best, or of average, trees was avoided, and as far as possible the trees were taken at random and an attempt was made to include all the trees in the nursery in trials.

Wootton's Crab. 95 two-year-old seedlings were planted in March, 1926, and budded the same year.

Although these were graded as before the smallness of the numbers made this of little value, as there were so few plants in each grade. Unfortunately these stocks occupied the outside row of a nursery, and so much treading of the ground took place from the adjacent foot-path that growth was very unsatisfactory. 55 standards were grown, but only 16 trees had made reasonably good growth by the time they were old enough to be planted out, and it is realised that the discarding of other poor trees is a weak point in this particular part of the trial. Full standards of Bramley's Seedling were again grown and all suitable trees available were included in grass orchard trials of layered stocks.

In February, 1927, a further 32 seedlings of this variety were planted in another part of the nursery and half of them were budded with Bramley's Seedling later in the year, while the other half were run up and head-worked with the same variety when they had reached standard height. Of these, 15 low-worked and 9 head-worked trees were eventually planted out in a grass orchard trial.

New Forest Crab. Two-year-old seedlings were planted, after grading, in February, 1928. The only grades represented were

Bc, Bd, Db, Dc and Dd, and the total number of stocks was 79. After budding with Bramley's Seedling in the same year 42 standard trees were obtained. In this and other parts of the nursery there were bad attacks of canker which rendered otherwise good trees unsuitable for planting; and only 17 of this set of trees were planted out for trial in a grass orchard among other standards on layered stocks.

Malus acerba. 190 seedlings of this variety were planted in February, 1930, after grading, and were budded with Newton Wonder in the same year. A number of stocks and maiden trees died, but 141 standard trees were left at the age of 4 years. Of these, 90 trees, together with 14 trees of a strong layered stock, have been planted in a grass orchard at the Research Station, while 8 trees were included in a trial of layered stocks in another grass orchard in Somerset. A number of trees could not be used owing to canker.

Clone Stocks. The clonal material used included Malling No.'s XII and XIII, and a number of clones, E7, F12, etc., raised at Long Ashton and still under trial.

In some years the clone stocks were graded before planting in the nursery, but in this case the grading was by weight and the grades do not correspond exactly with the grades of the seedling stocks. In other years only a single medium grade of clone stock was planted, the large and small plants being discarded.

RESULTS.

The data obtained from the material under observation are set out in Tables I—V, comparable sets of trees being grouped together in each table.

Stem diameters of trees, when moved from the nursery, are given in Table I. The figures for total shoot growth, for the first two years after budding, of the trees budded on seedling stocks in 1925 are given in Table II, which also includes the figures for comparable trees budded on several clone stocks at the same time. Similar data for shoot growth of other sets of trees were obtained but are not included in the table, as those given are typical of the whole series. Table III contains figures for the weights of trees, as dug from the nursery, on the seedling stocks, together with figures for comparable trees on clone stocks. Here again, for the sake of brevity, only part of the available data is presented. In Table IV the stem diameters of sets of trees when moved from the nursery, and of the same trees after several years growth in their permanent positions, are shown. Table V shows the height of head of three series of trees six years after planting in a trial plot.

The coefficients of variability of the various sets of measurements have been calculated and are shown in each table.

TABLE I.

STEM DIAMETERS OF STANDARD TREES WHEN REMOVED FROM NURSERY.

Stock.	*Scion Variety.*	*Budded.*	*Age when measured.*	*No. of trees.*	*Mean diameter (cm.)*	*Coefficient of Variability (V).*
E7 clone	Worcester	1923	4	16	2.1	13.1
F12 ,,	,,	,,	4	12	1.85	8.6
G6 ,,	,,	,,	4	19	1.9	9.7
G7 ,,	,,	,,	4	12	1.8	15.5
G8 ,,	,,	,,	4	34	2.2	11.5
G8 ,,	Bramley	1924	4	15	2.3	13.4
Mixed Seedlings	Bramley	1925	3	54	1.55	18.1
Hampshire Crab (all)	,,	,,	4	220	3.0	16.7
,, ,, (grade Bb)	,,	,,	4	11	2.8	10.0
,, ,, (,, Bc)	,,	,,	4	8	2.8	12.6
,, ,, (,, Bd)	,,	,,	4	21	2.8	16.4
,, ,, (,, Be)	,,	,,	4	10	3.3	13.8
,, ,, (,, Da)	,,	,,	4	17	2.8	13.4
,, ,, (,, Db	,,	,,	4	32	3.0	14.7
,, ,, (,, Dc)	,,	,,	4	42	3.2	18.9
,, ,, (,, Dd)	,,	,,	4	58	3.1	16.2
,, ,, (,, De)	,,	,,	4	21	2.9	13.4
E7 clone	Bramley	1926	5	52	3.0	10.1
F10 ,,	,,	,,	5	14	2.9	12.2
F11 ,,	,,	,,	5	26	3.1	12.3
G6 ,,	,,	,,	5	47	2.9	14.1
G7 ,,	,,	,,	5	51	2.6	16.2
G8 ,,	,,	,,	5	38	2.9	16.2
Wootton Crab	,,	,,	5	55	2.7	22.0
G7 clone (all)	Bramley	1927	5	50	3.0	13.7
G7 ,, (grade I)	,,	,,	5	15	3.0	10.8
G7 ,, (,, II)	,,	,,	5	18	3.1	10.7
G7 ,, (,, III)	,,	,,	5	9	2.7	21.3
G7 ,, (,, IV)	,,	,,	5	8	3.1	13.7
G8 ,, (all)	,,	,,	5	26	3.1	11.0
G8 ,, (grade I)	,,	,,	5	9	3.3	6.5
G8 ,, (,, II)	,,	,,	5	5	3.1	12.3
G8 ,, (,, III)	,,	,,	5	7	3.1	13.1
G8 ,, (,, IV)	,,	,,	5	5	2.9	8.4
Malling XII (all)	,,	,,	5	43	3.3	8.6
Malling XII (grade I)	,,	,,	5	17	3.1	7.3
Malling XII (,, II)	,,	,,	5	16	3.4	7.4
Malling XII (,, III)	,,	,,	5	8	3.3	7.8
Wootton Crab (all)	,,	,,	5	16	3.4	9.1
Wootton Crab (grade II)	,,	,,	5	6	3.4	5.4
Wootton Crab (,, IV)	,,	,,	5	7	3.4	9.9
Wootton Crab (headworked) (grade IV)	,,	,,	5	9	3.5	7.0
E7 clone (one medium grade)	Bramley	1928	5	27	3.2	13.8
G7 ,, (,, ,, ,,)	,,	,,	5	27	3.4	9.5
G8 ,, (,, ,, ,,)	,,	,,	5	25	3.7	9.0
Malling XII (one medium grade)	,,	,,	5	16	3.8	8.2
New Forest Crab (all grades)	,,	,,	5	42	3.5	10.6
E7 clone (one medium grade)	Newton	1930	4	33	2.7	21.8
G7 ,, (,, ,, ,,)	,,	,,	4	26	2.9	9.9
Malling XII (one medium grade)	,,	,,	4	33	3.1	10.8
W.C. clone	,,	,,	4	26	3.0	11.6
Malus acerba (all)	,,	,,	4	141	2.6	16.7
Malus acerba (grades a)	,,	,,	4	20	2.5	19.6
Malus acerba (,, b)	,,	,,	4	21	2.55	16.4
Malus acerba (,, c)	,,	,,	4	28	2.6	12.5
Malus acerba (,, d)	,,	,,	4	72	2.7	16.4

TABLE II.

TOTAL SHOOT GROWTH IN FIRST TWO YEARS AFTER BUDDING.

Stock.	*Scion Variety.*	*Budded.*	*No. of trees.*	*Mean length (cm.)*	*Coefficient of Variability (V).*
F10 clone	Newton	1925	13	159	12.2
F12 ,,	,,	,,	12	158	13.0
G7 ,,	,,	,,	12	166	12.3
G8 ,,	,,	,,	10	181	7.5
Mixed seedlings (all)	Bramley	,,	55	205	11.9
Hampshire Crab (Bb)	,,	,,	12	205	11.2
Hampshire Crab (Bd)	,,	,,	24	202	11.6
Hampshire Crab (Dc)	,,	,,	46	200	10.8

TABLE III.

WEIGHTS OF TREES AS DUG FROM NURSERY.

Stock.	*Scion Variety.*	*Budded.*	*Age when planted.*	*No. of trees.*	*Mean weight (gm.).*	*Coefficient of Variability (V).*
Malling XII	Bramley	1927	5	35	3150	17.0
Wootton Crab	,,	,,	5	15	3650	16.6
E7 clone	Bramley	1928	5	16	2770	14.1
Malling XII	,,	,,	5	8	3580	19.9
New Forest Crab	,,	,,	5	17	3160	18.9
E7 clone (one grade)	Newton	1930	4	33	2060	35.7
G7 ,, (,, ,,)	,,	,,	4	25	2490	16.6
Malling XII (one grade)	,,	,,	4	24	2700	25.0
W.C. clone	,,	,,	4	26	2490	30.5
Malus acerba (all)	,,	,,	4	135	1980	32.4

TABLE IV.

MAIN STEM DIAMETERS OF TREES IN PLANTATIONS.

Stock.	*Scion Variety.*	*No. of trees.*	*Diameter when planted (cm.)*	*Coefficient of Variability.*	*Years planted.*	*Diameter (cm.)*	*Coefficient of Variability. (V.)*
D1 clone	Newton	9	2.3	6.5	6	7.4	6.4
E7 ,,	,,	10	2.2	10.9	6	7.4	7.3
F11 ,,	,,	7	2.1	10.0	6	6.7	8.3
F12 ,,	,,	6	2.2	13.9	6	6.7	6.2
G6 ,,	,,	7	2.1	15.8	6	6.6	9.8
G7 ,,	,,	9	2.3	10.6	6	7.3	7.4
G8 ,,	,,	7	2.2	8.4	6	7.3	5.5
Malling XII	,,	10	2.4	8.7	6	8.1	5.2
Mixed seedling	Bramley	44	2.1	15.4	6	7.2	15.8
Hampshire Crab	,,	19	2.3	15.6	6	7.6	9.3
G8 clone	,,	15	2.3	13.4	6	7.7	7.7
F10 clone	Newton	5	2.3	7.3	4	3.4	14.7
G7 ,,	,,	6	3.1	9.6	4	4.2	17.5
Hampshire Crab	Bramley	37	3.6	10.4	4	4.8	9.7
Hampshire Crab	Bramley	47	3.3	10.6	5	5.5	16.6
E7 clone	Bramley	7	3.0	7.8	3	3.9	9.4
G8 ,,	,,	7	2.9	8.9	3	4.1	7.6
Malling XIII	,,	7	3.3	7.2	3	4.3	8.2
Wootton Crab	,,	7	3.0	9.7	3	4.0	10.2
E7 clone	Bramley	8	3.2	9.3	3	4.5	8.8
G6 ,,	,,	8	3.3	3.0	3	4.2	4.9
G7 ,,	,,	8	3.1	9.7	3	4.1	10.2
G8 ,,	,,	8	3.3	11.4	3	4.4	10.5
Malling XIII	,,	8	3.2	10.2	3	4.0	8.4
Wootton Crab	,,	7	3.6	11.0	3	4.6	6.7
Malling XII	Bramley	17	3.4	8.0	2	3.8	8.8
Wootton Crab	,,	15	3.4	8.6	2	3.8	9.1
Wootton Crab (head-worked)	,,	9	3.5	7.0	2	3.9	5.9

TABLE V.

HEIGHTS OF HEADS OF STANDARDS. BRAMLEY'S SEEDLING.

LONG ASHTON PLOT. 6 YEARS AFTER PLANTING.

Stock.	*No. of trees.*	*Height (cm.)*	*Coefficient of Variability(V).*
G8 clone	15	200	10.1
Hampshire Crab	19	210	10.6
Mixed Seedlings	44	200	15.4

DISCUSSION.

(i) Stem Diameters of Trees 3-5 years old. (Table I).

The value of V for a small number of trees worked on various clone stocks in 1923 is seen to vary between 8.6 and 15.5. These stocks were not graded and only a comparatively small number were available. The scion variety was Worcester Pearmain and there were no comparable trees on seedling stocks.

The only observations on trees worked in 1924 are from a small batch of Bramley's Seedling trees on one clone stock (ungraded). These trees may perhaps be compared with those worked in the following year. The value obtained for V was 13.4.

Bramley's Seedling trees worked on mixed seedlings in 1925 gave the figure 18.1 for V, while the trees on all grades of Hampshire Crab seedlings gave 16.7. The value of V for various grades of the latter stock varies between 10.0 and 18.9, but the differences in variability of the grades are probably not significant. There is a difference in the mean diameters of trees on the various grades of stock, but these differences are small and do not seem to be significant. In the " B " group of stocks the smallest seedlings (grade Be) have produced the largest trees ; but in the " D " group, the largest trees were found on the stocks of grade Dc, both the larger and smaller stocks producing smaller trees. The number of stocks in groups " A " and " C " were too small to provide any useful figures. The grading of the seedling stocks has apparently not resulted in a similar grading of the trees produced. The trees on both sets of seedlings, and especially on the mixed seedlings, were slightly more variable than those produced on the clone G8 in the previous year.

The Bramleys worked in 1926 show a variability of 10.1 to 16.2 for different clone stocks and 22.0 for Wootton Crab seedlings. As previously mentioned, soil conditions in this nursery were uneven, particularly as regards drainage, while the trees on the seedling stocks experienced exceptionally bad conditions. The distinctly greater variability of trees on the Wootton Crab may be due to this cause.

The variability of Bramley trees on the three clone stocks (all grades) worked in 1927 was 13.7, 11.0 and 8.6 respectively. It appeared that the variability in the separate grades might be either greater or less than the variability of all grades taken together, but the number of trees in each grade available for measurement was small. The grade of the stocks was not correlated with the size of the trees produced. The trees on Wootton Crab seedlings compared favourably with those on the clone stocks, the variability being 9.1 for 16 low-worked trees. The low figure of 7.0 was obtained for 9 head-worked trees.

Trees worked in 1928 on four clone stocks gave values for V of 13.7, 9.5, 9.0 and 8.2, while for New Forest Crab seedlings the figure was 10.6. Thus one layered stock showed more variability than the seedlings, but the others were slightly less variable. All the layered stocks in this case were of one medium grade, but the seedling stocks included all grades.

In 1930, the variety Newton Wonder was worked on several clone stocks, all of one medium grade, and on several grades of seedlings of *Malus acerba*. The trees on three of the layered stocks, with variabilities of 9.9, 10.8 and 11.6, were distinctly more uniform than those on seedlings, where the variability was 16.7, but one layered stock again produced more variability, the figure 21.8 being obtained. The grading of the seedling stocks apparently resulted in a slight but regular grading in the resulting trees, the largest trees being produced on the smallest stocks. This difference is probably not significant, and the different grades showed different values for V.

From the above results it appears that, under the conditions in which the trial was carried out, seedling stocks have usually given slightly more variable trees, as regards stem diameter at 3—5 years of age, than clone stocks. In some cases, however, clone stocks have produced the greater variation. Slightly more variable trees seem to have been produced by the use of mixed seedlings than by the use of seedlings from certain single varieties. The grading of stocks, either clone or seedling, before planting, has not resulted in more even sets of trees.

Although in some cases the standard errors of the coefficients of variability have been worked out and used to test the significance of the figures obtained, it does not appear that valid conclusions can be drawn concerning the significance, for in some cases one clone stock is found to be significantly more variable than another clone stock. Probably some of the variability is due to external factors, such as soil conditions, the effect of which, under the conditions of experiment, cannot be calculated.

(ii) Total Shoot Growth of Trees during First Two Years in Nursery. (Table II).

Data for shoot growth of two-year-old trees were obtained only from the trees worked in 1925. For rather small numbers of Newton Wonder trees on four different clone stocks, the variability was found to be 12.2, 13.0, 12.3 and 7.5.

Larger numbers of trees of Bramley's Seedling on mixed seedlings and on three grades of Hampshire Crab seedlings gave variabilities ranging from 10.8 to 11.9. According to this set of observations the variability on seedlings is no greater than that on clone stocks. The variability in shoot length is of the same order as the variability in stem diameter.

(iii) Weights of Trees as Dug from Nursery. (Table III).

The variability as expressed by these weights is in most cases greater than that calculated from stem diameters or lengths, but the method of making the observations may have introduced larger errors.

Two sets of Bramley's Seedling trees worked on a clone stock and on Wootton Crab seedlings in 1927 provided values for V of 17.0 and 16.6 respectively.

Among the 1928 trees, New Forest Crab seedlings gave the figure 18.9, which is intermediate between the figures 14.1 and 19.9 obtained from two clone stocks.

Trees of Newton Wonder worked in 1930 on four clone stocks (one grade) showed variabilities ranging from 16.6 to 35.7. A large number of trees on *Malus acerba* seedlings gave a variability of 32.4, which is about equal to the figures obtained from the two most variable clone stocks.

On the whole, clone and seedling stocks have produced similar amounts of variability in weight of trees.

(iv) Stem Diameters of Older Trees. (Table IV).

This table shows the mean stem diameters and coefficients of variability of various sets of trees several years after being planted in their permanent positions, and similar data for the trees at the time of planting are also included. When taking the trees from the nursery, a certain amount of selection usually took place, though no attempt was made to obtain the greatest possible uniformity. In the case of the mixed seedlings, however, practically every tree in the nursery was planted out. Owing to the necessarily limited size of the trial plots the number of trees on each clone stock is small.

The first set of trees shown in the table is growing in a cultivated plantation at Long Ashton. When planted, the plot was divided into two sections and half the trees on each stock were planted in blocks selected at random in each section. Most of the trees on clone stocks are Newton Wonders, but Bramley's Seedling is grown on one clone stock and on all the seedling stocks.

Among the trees on clone stocks the variability in stem diameter 6 years after planting ranges from 5.2 to 9.8, while the trees on Hampshire Crab seedlings give the figure 9.3, which is not significantly different from any of the others. The trees on mixed seedlings show a distinctly higher variability of 15.8. This high figure is due to one abnormally large tree and four unusually small trees. Though it is thought that the smallness of some of these trees very possibly may be due to some injury or disease the records at present available certainly indicate a considerably greater variability of the trees on the mixed seedlings.

A comparison of the figures obtained at the time of planting and six years later show that the variability has decreased in every case except that of the mixed seedlings. Records of individual trees on this and other plots show that, in general, the initial advantage of a larger tree on planting has been maintained in later years, but, as the annual increase in diameter has been the same for both large and small trees, the percentage differences have become less each year and the trees have tended to even up.

The next set of trees, growing in a grass orchard at Standish, Gloucestershire, includes a very small number of Newton Wonders on two clone stocks, and a larger number of trees on Hampshire Crab seedlings. Four years after planting the trees on clone stocks show the large variabilities of 14.7 and 17.5, which are greater than the variabilities when planted. The trees on seedlings are considerably less variable, the figure being 9.7. These figures are probably worthless as indications of the variability due to stock, as many of the trees have made very poor growth owing to bad drainage conditions, which actually caused the death of a number of trees, including some on other clone stocks. The results obtained in this orchard offer a good example of the way in which stock influence may be entirely overshadowed by soil conditions.

The above remarks also apply to the next set of trees, growing in a grass orchard at Rodley, Gloucestershire. Here similar conditions existed, though more drainage has recently been carried out, and trees have died or been badly checked. The variability of the 47 Bramley's Seedling trees on Hampshire Crab seedlings after five years is 16.6, compared with the figure of 10.6 for the same trees when planted.

The last three sets of trees shown in the table are barely well established yet, especially as they have had two very dry years since planting. Bramley's Seedling trees on three clone stocks in a grass orchard at Dymock, Gloucestershire, show variabilities of 9.4, 7.6 and 8.2, while trees on Wootton Crab seedlings in the same orchard give the figure 10.2, which is not significantly different.

Another set of trees planted at the same time as the last, in a grass orchard near Bromham, Wiltshire, shows a similar result. The variability on the clone stocks is usually between 8.4 and 10.5, though on one stock the figure is 4.9. On seedlings of Wootton Crab the variability is 6.7.

The last set of trees shown in the table was planted two years ago at Rodney Stoke, Somerset. The values for V of Bramley's Seedling trees on a clone stock and on Wootton Crab seedlings are 8.8 and 9.1. Trees head-worked on the same variety of seedlings give the lower figure of 5.9.

In the last three sets of trees the variabilities at the latest date of observation differed but slightly from those at the time of planting, as the trees had not yet made any large amount of growth. Trees on New Forest Crab seedlings and *Malus acerba* seedlings are not yet old enough to have provided any data beyond the nursery stage.

(v) Heights of Heads of Standard Bramley's Seedling. (Table V).

These trees are the same as those yielding the stem diameter measurements in the first part of Table IV. The height of the head is measured from the base of the lowest branch. It is seen that the coefficient of variability of the height of the heads six years after planting is 10.1 for the clone stock and 10.6 for the Hampshire Crab seedlings. The mixed seedlings give the higher figure of 15.4.

(vi) Other Data.

From the same three sets of Bramley's Seedling trees in the Long Ashton plantation, data have also been obtained concerning the spread of the branches, the number of flower trusses and the number and weight of fruits borne, but no figures are given here. The variability of the spread is, in each case, rather greater than that of the height or stem diameter. As none of the trees bore any considerable amount of blossom or fruit before last year the variabilities found for these observations are very large, and are probably of little value for the purpose of comparison. All these data, however, indicate practically equal variabilities for the clone stock and the Hampshire Crab seedlings, but a considerably higher variability for the mixed seedlings.

SUMMARY AND CONCLUSIONS.

Standard trees have been grown on clone stocks, and on seedling stocks obtained from various sources.

Records of the size of the trees, chiefly as measured by stem diameter, have been kept. The figures are given, together with the coefficients of variability in each case.

On the material investigated, the size of young trees, up to five years of age in the nursery, does not appear to be significantly more variable on mixed seedling stocks or on seedlings of four separate varieties, than on clone stocks.

Grading of either seedling or clone stocks before planting in the nursery has not resulted in greater uniformity of the trees.

Trees in orchards six years or less after transplanting from the nursery, were found to be equally variable on clone stocks and on single variety seedling stocks. Variability is greater on the mixed seedling stocks, where the trees were all transplanted from the nursery entirely without selection.

The trees have not yet provided data on the variability of blossom formation and cropping.

Acknowledgments.

The writer wishes to acknowledge the assistance, first of Mr. J. E. Shaw and, later, of Mr. G. E. Clothier, who recorded a large number of the measurements taken in the investigations.

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COMPARATIVE YIELDS OF BLACKCURRANT VARIETIES AND THEIR RESPONSE TO DIFFERENTIAL PRUNING TREATMENT.

By T. SWARBRICK and W. E. BERRY.

The design of these variety trials and layout of the plots have been described in detail in previous Annual Reports (1931 and 1934), when preliminary results were discussed with special reference to the incidence of " reversion," control of " big bud " and the comparative costs of picking the several varieties. The present paper contains a final report on the cropping of the six varieties and the effect of hard and light pruning respectively on the yields for the 7-year period, 1930-36 inclusive.

Two separate trials have been run concurrently with material of different origin. Two-year-old bushes of the varieties Boskoop, Baldwin, Taylor and Davison's Eight (Westwick) were supplied by the Royal Horticultural Society and are referred to collectively as the " Wisley " material. The second group of bushes, referred to as Long Ashton material, comprised 184 bushes of each of the four varieties Boskoop, Baldwin, Edina, and French (Seabrook's Black). A straightforward variety trial was carried out on the Wisley material, and observations on the incidence of reversion were made. The Long Ashton varieties were similarly compared, but were used in addition to study the effects of hard and light pruning and the spread of reversion from known sources of infection. The data relative to reversion are discussed in a later paper in this Report.

A. WISLEY MATERIAL.

Experimental.

Planting. The two-year-old bushes were planted in the winter of 1928-29, at distances of 6 by 5 feet, in 26 randomised blocks, each block consisting of 4 plots, each containing 4 bushes of a variety. The distribution of the plots is given in the planting plan in the later paper in this Report (p. 125) in which data on reversion are discussed in detail for the same material.

Pruning Methods. Pruning was uniform throughout, consisting of a complete cutting down to ground level after planting, followed by the removal of about one-third of the bush during each subsequent winter. Shoots were never tipped but complete branches of old wood were removed as near the base as possible. By this method the bushes were kept open and a sufficient supply of new shoots developed by the rapid growth of basal buds from the stubs left after pruning. As compared with the " hard " pruning, to be described later for the Long Ashton material, this treatment is designated " light."

Cultivation and Manuring. Spring cabbage was grown on the plot in 1926 and was followed by a bare fallow in 1927. In autumn 1927 farmyard manure at the rate of 40 tons per acre was applied and ploughed in, this being the only dressing of organic manure applied in any form. The manurial treatment in subsequent years generally consisted of a mixture of 3 cwts. nitrate of soda, 3 cwts. superphosphate and 1 cwt. sulphate of potash, applied during March.

Clean cultivation was practised as far as possible. By 1931, however, the bushes had become so large as to prevent effective horse cultivation except in winter, and from 1933 onwards all the work had to be done by hand. This latter cultivation has consisted of a winter digging and summer hoeing, which has not, however, been sufficient to prevent a progressive invasion of the plot by couch and water grass. Pest and disease control has been better than the average, the routine applications of winter wash, lime sulphur, and Bordeaux mixture having provided an adequate control of the usual insect and fungus pests throughout the experimental period.

Results.

Records of yields in kilogrammes were kept for each individual bush, and the average annual yields per bush for each variety were calculated. These are set out in Table 1A for the period 1930-36 inclusive. Reverted bushes on these plots were very few and for the purpose of this comparison are excluded from the averages, which therefore represent bushes which remained clean and healthy throughout the experiment, usually about 90 of each variety. The yields per acre, calculated on the basis of a 6 by 5 feet planting distance, are given in tons. It is clear that the varieties Boskoop and Baldwin, with total yields of 18.26 and 15.85 tons per acre respectively, are approximately twice as prolific as Davison's Eight and Taylor which give respectively 8.63 and 7.60 tons for the same period. The mean annual yields per acre illustrate the same differences.

The strikingly low yields of Davison's Eight and Taylor are closely related to the amount of growth made by these varieties. Both sorts present a rather gaunt and bare appearance and the response to pruning has been most unsatisfactory. Whilst Boskoop and Baldwin normally developed two or three shoots from the stub left after pruning, Davison's and Taylor rarely produced more than one. Moreover, the two latter varieties have proved more susceptible to damage by lime sulphur spray and late spring frosts. Frost damage in these sorts is probably related to the fact that the flowers are not so well protected by the foliage as, for example, those of Boskoop, and have consequently suffered severely in this experiment from the unusually frequent occurrence of late frosts between 1930 and 1936. In view of these several weaknesses, Davison's Eight and Taylor may be regarded as decidedly unsuitable varieties for the environmental conditions obtaining at Long Ashton.

TABLE I.

MEAN YIELDS PER BUSH (KILOS) AND MEAN ANNUAL YIELDS PER BUSH AND PER ACRE (TONS).

A. WISLEY MATERIAL.

Variety.	1930.	1931.	1932.	1933.	1934.	1935.	1936.	*Mean for 7 years.*	*Calculated Total Yield per acre. (tons.)*	*Mean Annual Yield per acre. (tons.)*	*Mean Annual Yield per acre of Reverts. (tons.)*
Boskoop	0.92	2.83	1.76	2.05	1.85	1.28	0.90	**1.66**	18.26	**2.61**	1.18
Baldwin	1.21	1.64	1.77	1.32	1.37	2.21	0.56	**1.44**	15.85	**2.27**	1.84
Davison's	0.40	0.52	1.17	1.14	1.25	0.53	0.46	**0.78**	8.63	**1.23**	0.87
Taylor	0.53	0.75	0.80	0.66	0.83	0.48	0.78	**0.69**	7.60	**1.09**	No reverts.

B. LONG ASHTON MATERIAL.

Variety.	1930.		1931.		1932.		1933.		1934.		1935.		1936.		*Mean for 7 years.*		*Calculated Total Yield per acre. (tons.)*		*Mean Annual Yield per acre. (tons.)*		*Mean Annual Yield per acre of Reverts.*	
	Light.	*Hard.*	*Light.*	*Hard.*	*Light.*	*Hard.*	*Light.*	*Hard.*	*Light.*	*Hard.*	*Light.*	*Hard.*	*Light.*	*Hard.*	*Light.*	*Hard.*	*Light.*	*Hard.*	*Light.*	*Hard.*	*Light.*	*Hard.*
Boskoop ..	1.13	0.76	2.31	1.99	1.79	1.80	1.61	1.76	1.66	2.10	1.20	0.97	1.21	1.14	**1.56**	**1.50**	17.17	16.56	**2.45**	**2.34**	1.09	1.90
Baldwin ..	1.70	1.35	1.58	1.37	1.58	1.55	1.18	1.03	1.43	1.17	1.78	1.65	0.67	0.59	**1.42**	**1.24**	15.63	13.70	**2.23**	**1.96**	1.69	0.27
French ..	1.04	0.78	2.34	2.02	2.23	1.96	1.95	1.77	1.84	1.68	1.48	1.04	1.48	1.49	**1.77**	**1.54**	19.47	16.90	**2.78**	**2.41**	1.63	1.36
Edina ..	1.37	0.98	1.83	1.44	2.01	1.88	2.00	1.73	2.07	2.06	0.86	0.78	1.07	1.37	**1.60**	**1.44**	17.66	16.11	**2.52**	**2.30**	1.35	1.38

Statistical Analysis of the Yield Data. The yields from each individual plot, *i.e.* total yield of 4 bushes, were treated statistically by Fisher's method for analysis of variance. The statistics derived are summarised in Tables II and III, from which it is clear that the differences between varieties already discussed are highly significant. There is also a significant difference due to soil variation, but since this is unimportant for our present purpose it is not further discussed.

TABLE II.

ANALYSIS OF VARIANCE.

Variation due to	*Degrees of Freedom.*	*Sum of Squares.*	*Mean Square.*	*½ ln Variance.*	*Z*	*1% Table.*
Blocks ..	25	1663	66.5	2.098	0.542	0.35 approx.
Varieties ..	3	16008	5336.0	4.289	2.733	0.7 approx.
Remainder (Error)	75	1692	22.5	1.556	—	—

TABLE III.

SIGNIFICANCE OF DIFFERENCES BETWEEN VARIETIES.

Variety.	*Boskoop.*	*Baldwin.*	*Davison's 8.*	*Taylor.*	*Mean.*	*S. Error.*
Total Yield	1282.3	1017.0	561.8	502.5	843.4	24
% of Mean	152.0	120.6	66.6	59.4	100	2.85%

B. LONG AŞHTON MATERIAL.

Experimental.

Arrangement of Plots. The previous history, planting distance, cultural and manurial treatment and spraying programme were the same for this plot as for the Wisley material. A plan of the plot is given on p. 125 of this Report. The bushes are arranged in eight blocks, each containing a single plot of 23 bushes of each variety, making 32 plots in all. The plots are separated by single buffer rows of French. In each of the 8 plots of the variety French, one bush known to be infected with reversion was planted to act as a centre from which any spread of reversion could be followed. The yields of these additional 8 bushes were not included in the recorded total yields for the different plots.

Pruning Treatments. Two distinct methods of pruning were adopted and designated " light " and " hard " respectively. Light pruning was carried out as already described for the Wisley material. Hard pruning consisted of the removal each winter of two-thirds of the bush, old branches being removed at the base as in light pruning. This is a particularly drastic treatment, and as might be expected, bushes so treated are much smaller than those given the light pruning treatment. The two treatments were not randomised over the whole plot ; the northern half of the plot was light pruned and the southern half hard pruned. Whilst this makes the randomisation of the whole experiment incomplete it does not seriously vitiate the statistical treatment of the results and from the practical point of view, plot management was made easier. As for the Wisley material, yields of individual bushes were recorded each year.

Results.

The collected data are arranged in Table 1B, from which it is clear that the various varieties show appreciable differences in regard to mean annual yield per acre. French gives the highest yield and Baldwin the lowest, whilst Boskoop and Edina do not differ appreciably. The effect of pruning is more marked. The average crop for all four varieties is considerably reduced by hard pruning as compared with light. In the case of Boskoop the loss of crop due to hard pruning over the whole period amounts to about 12 cwts. For Baldwin it is nearly 2 tons, for French about 2½ tons, and for Edina 1½ tons. In terms of cash return per acre the loss in crop is considerable, amounting, at the rate of £40 per ton to £100 in the case of French and to £26 in the case of Boskoop over the seven year period. It is clear, therefore, that hard pruning may result in a considerable loss of income by reduction of crop, whilst further loss is incurred in view of the longer time required to carry out the harder pruning.

Statistical Treatment of the Data. The data in Table 1B are derived from the average yields of healthy bushes only, as it seemed more useful from the practical point of view to compare bushes free from reversion. There is, however, a considerable number of reverted bushes in the Long Ashton material, spread over the whole plot. With this degree of infestation, it was felt that the calculation of artificial plot values from the yields of the remaining healthy bushes in a plot would give an unreal comparison between the varieties, and it was therefore decided for statistical purposes to include the reverted bushes in the plot yields. The reduction in yield due to reversion is thus treated as a normal source of variation between the varieties.

Since there were eight plots of each of four varieties, and two pruning treatments, each treatment was replicated four times in a variety. There are thus three relevant variables: soil, variety, and pruning treatment, contributing respectively 3, 3 and 1 degrees of freedom. Variations due to these three were resolved by analysis of variance according to Fisher's method and the interactions between soil and variety, variety and pruning, and pruning and soil were calculated. The relevant data are given in Tables IV, V and VI. As none of the three interactions, nor the variation due to soil, proved significant these are not further discussed.

TABLE IV.

ANALYSIS OF VARIANCE.

Variation due to	*Degrees of Freedom.*	*Sum of Squares.*	*Mean Square.*	*½ ln Variance*	*Z*	*1% Table.*
Soil	3	377	125.7	—	—	—
Varieties	3	14614	4871.3	4.2454	1.4218	0.972
Pruning	1	6176	6176.0	4.3642	1.5406	1.178
Interactions :—						
Variety x Pruning..	3	2272	7573.3	3.3147	0.4915	0.972
Variety x Soil ..	9	4355	483.9	3.0909	0.5346	0.849
Pruning x Soil ..	3	1275	425.0	3.0260	0.2024	0.972
Error	9	2551	283.5	2.8236	—	—
Total	31					

TABLE V.

SIGNIFICANCE OF DIFFERENCE BETWEEN VARIETIES.

Variety.	*Boskoop.*	*Baldwin.*	*French.*	*Edina.*	*Mean.*	*S. Error.*
Total Yield..	1975.3	1691.6	2170.0	1976.7	1953.4	47.62
% of Mean	102	86.6	111	102	100	2.44%

TABLE VI.

SIGNIFICANCE OF DIFFERENCE BETWEEN PRUNING TREATMENTS.

Treatment.	*Hard.*	*Light.*	*Mean.*	*S. Error.*
Total Yield ..	3677	4136	3907	67.6
% of Mean ..	94.1	105.9	100	1.73%

It is evident from the statistics calculated (*a*) that the differences in yield due to differential pruning are highly significant, (*b*) that the yield of the variety French is significantly greater than that for any other variety, whilst Baldwin gives the lowest yield, and Boskoop and Edina do not differ significantly from each other.

GENERAL NOTES AND DISCUSSION.

The figures given in Table I may be taken as a general guide to the yields which may be expected from these varieties with conditions and treatment similar to those described. Climatic conditions during the period of the trial were by no means ideal, the crops having been reduced during the seven years concerned by three late spring frosts, and by a severe drought in the season 1933-34. In 1936, the crops of Boskoop, Baldwin and Edina suffered an unusually excessive reduction due to the relatively forward condition of the bushes and the unfortunate occurrence of a late frost on the night after they had been sprayed with lime sulphur.

The crops might have been increased, particularly in the later years, by more intensive cultivation, but, as already indicated, weed control became increasingly difficult as the bushes increased in size. Nevertheless, with the conditions as described, annual yields of over 2½ tons per acre for seven years for the varieties Boskoop, French and Edina, and over 2 tons for Baldwin are regarded as satisfactory, and indicate that these four varieties may all be considered as possible sorts for commercial planting in similar conditions. It is worthy of note that the four varieties cover the requirements of the normal range of commercial blackcurrants. Boskoop, in view of its earliness in season, should be considered as mainly suitable for the domestic market. During the seven years under review, this variety has realised at least £4 per ton more than any other sort when sold through the normal wholesale channels. The other varieties are all suitable for supplying fruit on contract in relatively large quantities.

A further point of interest is that the variety Baldwin produced its maximum crop in the sixth year after planting, 1935, the year of the severe spring frost on May 16th, which seriously reduced the yields of Edina, Davison's Eight and Taylor. Since Baldwin showed a high yield for both the Wisley and Long Ashton material as well as for the hard and light pruned bushes, conditions must have been very favourable for this variety, in spite of the disastrous frost. This marked varietal difference in respect of frost damage illustrates the importance of weather conditions in determining varietal yield, and the necessity for recording yields over periods of several years.

A striking illustration of the effect of reversion on yield is provided by the data in the last column of Tables I A and I B, where the calculated yields per acre for reverted bushes are presented. Comparing these with the yields from healthy bushes it will be seen that reversion has reduced the yields considerably for all varieties, the reduction amounting in some cases to more than 50%, or upwards of a ton per acre per annum. This is a strong argument for the maintenance of plantations free from this disease, and growers will find it economical to plant as far as possible only clean and healthy stocks, and to remove and replace with clean bushes during the early life of the plantation any which show symptoms of reversion.

SUMMARY.

1. Variety trials have been carried out on two sets of black-currant material. In one case the varieties Boskoop, Baldwin, Davison's Eight and Taylor were compared, and in the other, Boskoop, Baldwin, French and Edina.

2. All these varieties were found to crop satisfactorily except Davison's Eight and Taylor. Differences between the varieties are discussed and the yields examined statistically.

3. A comparison of hard and light pruning on the varieties Boskoop, Baldwin, French and Edina showed that hard pruning reduced the crop significantly in every case.

4. The importance of the results in commercial practice, and the reduction of crops by Reversion are discussed.

A SUMMARY OF FRUIT SPRAYING PROGRAMMES.—I.

By H. G. H. KEARNS and R. W. MARSH.

During the past few years considerable advances have been made in the control of fruit pests and diseases, particularly by the use of combined washes including materials of fungicidal and of insecticidal properties. A knowledge of the pests, diseases, spray materials and reactions of host plants at various periods of growth is necessary to formulate an economical and successful spray programme. Certain of the pests such as Apple and Plum Sawflies, Fruit Tree Red Spider and Codling Moth can be controlled only by the application of washes within a specific short period of time. Thus in the case of the above mentioned species of sawflies the incorrect timing of an application amounting to as little as 3—5 days will result in unsatisfactory control of the pests. The optimum periods of spray application for certain pests vary within the Bristol Province according to locality and altitude; thus the spray date for Apply Sawfly in Somerset is usually a week earlier than in Worcestershire, and for apples grown at 500 feet above sea level usually a week later than for those nearby at 150—200 feet elevation. It should be noted that the dates of application of washes are subject to seasonal variations.

It is for these reasons that Long Ashton Research Station, in collaboration with the County Agricultural Departments of the Bristol Province, has started a spray programme service. Each season information concerning the composition of washes and relating to the major fruit pests and diseases will be distributed to growers by means of leaflets and press notices. Unfortunately, with some of the pests, it is not possible to predict the spray dates with certainty sufficiently in advance to allow of long-time notice and in such cases it is only possible to distribute the information immediately prior to the correct spraying date. This frequently does not provide all growers with sufficient warning to purchase the requisite spray materials. An indication of the materials likely to be needed for various purposes is therefore given in the present article which is designed to provide a summary of the standard spray programmes now used in commercial orchards in the Bristol Province. It is intended that this account should serve as a background to the spray programme service and to articles on specific subjects which are contributed by Long Ashton Research Station in the County Agricultural Journals of the Province.

The list below covers the remedial measures ordinarily employed but is not to be regarded as a complete calendar of fruit pest and disease control.

The spray programmes described concern the following plants :—

I. Apple.
II. Pear.
III. Plum.
IV. Cherry.
V. Blackcurrant.
VI. Redcurrant.
VII. Gooseberry.
VIII. Raspberry.
IX. Loganberry.
X. Blackberry.
XI. Strawberry.

I.—APPLE.

Programme.

	Stage	*Approximate date of spraying.*	*Materials per* 100 *gallons water.*	*Pests and Diseases Controlled.*
1	Dormant	Dec-mid Feb.	4–7½ gall. tar oil emulsion	Aphides Sucker (*P. mali*)
2	Delayed dormant	Late March	6–7½ gall. petroleum oil emulsion	Capsids (*P. rugicollis* and *L. pabulinus*) Red Spider (*O. ulmi*) (partial control)
3	Greenflower	April 15—25	3 gall. lime sulphur	Scab
4	Pink Bud	May 1—8	3 gall. lime sulphur 2 lb. lead arsenate powder or equivalent	Scab " Caterpillar "
5	80 per cent. Petal-fall	May 18—30	8 oz. nicotine 2 lb. lead arsenate powder or equivalent ½ lb. wetter* or 1 gall. white oil emulsion	Sawfly Capsid Winter Moth Codling Moth
5a	7 days after stage 5		8 oz. nicotine ½ lb. wetter* 1 gall. lime sulphur	Sawfly Capsid Red Spider Scab
6	3 weeks after petal-fall	June 15—22	1 gall. lime sulphur	Scab
7	1st Codling Cover Wash	July 1—10	3 lb. lead arsenate powder 1 gall. white oil emulsion	Codling Moth

* *e.g.*—the proprietary water-soluble wetters Agral 2 or Lethalate Wetting Preparation or Sulphonated Lorol.

	Nursery Stock.			
1	Dormant	Dec.-mid Feb.	4–7½ gall. tar oil emulsion	Aphides Sucker
5	Equivalent to petal-fall of mid-season flowering varieties	May 18—30	8 oz. nicotine 1½ gall. white oil emulsion	Aphid Woolly Aphid Red Spider Capsids
6	3 weeks after petal-fall	June 15—22	8 oz. nicotine 1½ gall. white oil emulsion	Woolly Aphid

Specifications for Materials.

Tar Oil Wash. The tar oil wash must be applied at a concentration of not less than 2.5 per cent. neutral, high boiling tar oil soluble in dimethyl sulphate to ensure a complete control of sucker and aphides (15, 21, 22). The composition of proprietary washes varies considerably and concentrations from 4 to 7½ per cent. are necessary to provide the necessary minimum of ovicidal tar oil.

Petroleum Oil Wash. High boiling petroleum oils conforming to the specification of Grade E (21) are recommended at a concentration of not less than 5 per cent. to ensure a satisfactory control of capsid bugs.

Combined Tar Oil-Petroleum Washes. The combined wash must be applied at a concentration that ensures the minimum amount of tar and petroleum oils stated above.

White Oil Emulsion. A white oil emulsion for summer use should be prepared with an oil conforming to specification G (21). An oil of unsulphonated residue of less than 90—92 should not be used after the delayed dormant stage. If the emulsion is used with lead arsenate or lime sulphur it should be emulsified with sulphite lye (1). The oil emulsion concentrate quoted in the programme contains 66 per cent. oil.

Lead Arsenate. Lead arsenate in powder, paste or colloidal form may be used. The colloidal material is well suited for the first post-blossom wash (No. 5), but if used in conjunction with lime sulphur it may result in foliage damage. The amount of lead arsenate should be equal to 2 lb. in dry weight; 4 lb. of paste and 1 quart of colloidal arsenate are each equivalent to 2 lb. powder.

The remainder of the materials with the exception of proprietary products should conform to the standards laid down by the Ministry of Agriculture and Fisheries (23).

Alternative Spray Materials.

Combined Tar Oil-Petroleum Wash. Although the separate applications of tar and petroleum emulsions is the best means of ensuring control of a severe infestation of capsid bugs, there are times when a combined tar oil-petroleum wash may be preferred. A wash of this type is used at high concentration of oils and must be applied not later than mid-February in order to reduce the risk of bud damage. Usually the wash does not provide a satisfactory control of Red Spider (*O. ulmi*) but ensures an effective control of Winter Moth (*C. brumata*).

Bordeaux Mixture. Bordeaux mixture may be used instead of lime sulphur on varieties not copper sensitive (see under). If a copper spray is required for use in mixed washes it is preferable to employ a cotton seed oil-Bordeaux spray made up of 4 lb. copper sulphate and 6 lb. hydrated lime per 100 gallons water to which is added 6 pints of oil.

Supplementary Control Measures.

Winter Moth. The combination of efficient winter washing and the pre-blossom applications of lead arsenate generally provide a satisfactory control of the larvae of the Winter Moth. In some circumstances grease banding may be preferred. The banding should be carried out in October and the grease regularly raked over from early November until late December, the period that coincides with the emergence of the majority of the moths.

Blossom Weevil. Applications of Derris dusts at the early green-flower stage do not provide a sufficiently high control to warrant the expense. Sack banding applied to the boles of the trees in June at times provides a means of capturing large numbers of weevils. It is desirable that the bands be removed from the trees before the end of October, and the weevils killed by immersing the sacking in Derris wash. If the removal of the bands is postponed until later many of the weevils will leave and find fresh hibernating quarters in hedgerows, etc., well away from the tree.

Codling Moth. Sack banding applied to smooth barked trees at the times mentioned above for Blossom Weevil provides a means of capturing large numbers of Codling larvae. On older trees the larvae hibernate beneath the rough bark in preference to beneath the sacking, and therefore rough bark must be removed by means of a scrape before applying the bands.

Modifications for Variation in Pest and Disease Intensity.

Winter Moth and Tortrix Moths. Lead arsenate should be added to the greenflower (stage 3) lime sulphur wash if Winter Moth and Tortrix Moth larvae are prevalent.

Apple Sawfly. Double spraying (5 and 5*a*) is strongly recommended when the sawfly infestation is severe. If the infestation is not serious the following single application of a combined wash should be given at stage No. 5.

8 oz. nicotine.
1 gall. white oil emulsion (sulphite lye emulsifier).
1 gall. lime sulphur.
100 gall. water.

The lime sulphur must be omitted on sulphur-shy varieties. The oil emulsion will provide a control of Red Spider.

Codling Moth. Nicotine sulphate 20 fl. oz. per 100 gall. is suggested as a substitute for lead arsenate on very early varieties, such as Beauty of Bath, in order to avoid the risk of excess arsenical residues on the fruit at the time of picking. A second cover wash applied at the end of July may be necessary to control severe infestations. It should consist of nicotine sulphate and white oil emulsion and only be applied to late varieties.

Scab. Application 6 is necessary only in wet summer or where scab attack is unusually heavy.

Modification of Programme for Varieties.

Copper sensitive varieties, such as Cox, Grieve, Worcester, should not be sprayed with Bordeaux mixture or any other copper fungicides after April.

Sulphur sensitive varieties, such as Stirling Castle and Lane's Prince Albert cannot be treated with any form of sulphur after blossoming without risk of damage.

References :—1, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 23.

II.—PEAR.

	Stage.	*Approximate date of spraying.*	*Materials per* 100 *gallons water.*	*Pests and Diseases Controlled.*
1	Dormant	Dec.-Jan.	4–7½ gall. tar oil emulsion	Aphid
2	Delayed Dormant	End of March	3 gall. lime sulphur	Scab
3	Greenflower	Mid April	3 gall. lime sulphur 2 lb. lead arsenate powder	Scab Winter Moth
4	White-bud	End of April	1 gall. lime sulphur 2 lb. lead arsenate powder	Scab Winter Moth
5	Petal-fall	Mid May	1 gall. lime sulphur	Scab
6	3 weeks after petal-fall	End of May	1 gall. lime sulphur	Scab
7	6 weeks after petal-fall	Mid June	1 gall. lime sulphur	Scab

Specification of Materials.

See apple programme.

Alternative Spray Materials.

Bordeaux mixture may be used instead of lime sulphur.

Other Control Measures.

Winter Moth. As Winter Moth is frequently a serious pest of pears, grease banding should be carried out in those orchards subject to severe infestations. In some circumstances it may be necessary to add lead arsenate to the post-blossom wash. (Application 5.)

Capsid Bugs. The Capsid Bugs (*P. rugicollis* and *L. pabulinus*) are both responsible for corky markings on pears. The capsids must be controlled after petal fall, and this control may be obtained by the addition of 8 oz. of nicotine and ½ lb. water-soluble wetter (as described for apple pests) in sprays Nos. 5 and 6. Grease banding just before the petal fall application is recommended, or if grease bands are already on the trees, they should be combed over to expose a fresh surface. The banding material prevents the ascent of capsids which often wander from other host plants.

Pear Slugworm or Sawfly. This pest can cause rapid and serious defoliation, particularly in young plantations. There are two principal broods. The first brood of larvae is easily controlled by the addition of 2 lb. lead arsenate powder to wash No. 6. The second brood is best controlled by the application in mid-July of a wash containing 6 oz. nicotine and ½ lb. of wetter to 100 gallons of water or 1½ lb. Derris or barbasco root (containing not less than 1.5 per cent. crystalline rotenone) may be substituted for the nicotine.

Pear Midge. This pest may be considerably checked when the trees are grown on light soil by the application in March of calcium cyanide to the ground at the rate of ½ oz. per square yard.

The addition of 8 oz. nicotine and ½ lb. wetter to the "white bud" wash is also worthy of trial. The application must be made as soon as the first portion of white colour appears on the flower buds.

Remarks.

The number of applications of fungicidal post-blossom washes is determined by the intensity of the scab attack: in general, scab of pears is more difficult to keep in check than that of apples.

The variety Doyenne du Comice is subject to both copper and sulphur injury when sprayed after petal fall.

References :—17, 19.

III.—PLUM.

	Stage.	*Approximate date of spraying.*	*Materials per 100 gallons water.*	*Pests and Diseases Controlled.*
1	Dormant	December to mid January	4–7½ gall. tar oil emulsion	Aphides
2	"Cots" splitting	May 10—20	Derris (see under) 1 gall. white oil emulsion	Plum Sawfly Winter Moth
3	7 days later		Derris (see under) 1 gall. white oil emulsion	Plum Sawfly Winter Moth Red Spider

Specification of Materials.

For tar oil emulsions, white oil emulsions and lead arsenates, and wetter see apple programme.

Derris. The amount of Derris or Derris extract required depends on the rotenone content. The wash should contain not less than 0.004 per cent. of crystalline rotenone.

Alternative Spray Materials.

Barbasco or any other rotenone-containing material may be used as a substitute for derris provided it is suitable for use with a white oil emulsion.

Supplementary Control Measures.

Grease banding for the control of Winter Moth is important on plums. The grease band should be carefully applied to ensure that all the crevices of rough bark are included. The grease must be regularly combed during the period of early November to the end of December.

The pruning of plum trees during autumn is to be avoided since the likelihood of infection by silver leaf and bacterial canker is then at its greatest. In glut years fruit should not be left on the trees nor should fruit be permitted to rot undisturbed because this procedure increases the risk of brown rot.

The Wood Scolytid Beetles (Wood Borers) are not primary pests of the tree, but their presence invariably indicates that the tree is in a low state of vigour due to unsatisfactory soil or manurial conditions, or as a result of over-cropping or following severe loss of foliage by insect attack.

Modifications for Pest and Disease Intensity.

If Plum Sawfly is absent it will still be necessary to spray for the control of Red Spider. Either a white oil emulsion or 1 gallon lime sulphur with ½ lb. wetter per 100 gallons should be applied after the " cots " have split. If Winter Moth larvae are prevalent lead arsenate may be added to the Red Spider wash. In some seasons of severe caterpillar infestation it may be necessary to apply the lead arsenate in early May.

Modifications of Programme for Variety.

Victoria and other loose-scaled varieties are more subject to tar oil injury and should therefore be sprayed before Christmas.

Early Rivers is sulphur-sensitive ; Purple Pershore is subject to arsenical injury and a combined lime sulphur and lead arsenate wash cannot be safely applied to this variety.

References :—4, 8, 15, 22.

IV.—CHERRY.

Stage	*Approximate date of spraying.*	*Materials per* 100 *gallons.*	*Pests and Diseases Controlled.*
Dormant	Dec.-Jan.	4–7½ gall. tar oil emulsion	Aphid
	Mid June	Derris (see under) ½ lb. wetter	Cherry Sawfly (1st Brood)
	August	2 lb. lead arsenate powder or equivalent ¼ lb. wetter	Cherry Sawfly (2nd Brood)

Specification for Materials.

For tar oil emulsion, Derris and wetter see apple and plum.

Supplementary Control Measures.

Winter Moth is best controlled by means of efficient grease banding (see plum).

Modifications for Pest and Disease Intensity.

If grease-banding is omitted and caterpillar attack proves serious it is necessary to apply a lead arsenate wash in spring, not later than the first week in May.

Cherry Sawfly (*Eriocampa limacina* Cameron). It is desirable to control the first brood of larvae in June by means of a Derris wash in order to avoid any poisonous deposit on the fruit. The second wash can often be omitted if the first spraying is carried out efficiently.

References :—4, 8, 15.

V.—BLACK CURRANT.

	Stage.	*Approximate date of spraying.*	*Materials per* 100 *gallons.*	*Pests and Diseases Controlled.*
1	Dormant	Dec.-Feb.	4–7½ gall. tar oil emulsion	Aphid only
or 1a	Just prior to bud burst	Mid-end Feb.	10–12 gall. tar oil-petroleum emulsion	Aphid, Capsid Winter Moth
2	Tight cluster*	Early April	4–8 gall. lime sulphur ½ lb. wetter	Big Bud Mite
3	After picking	Mid-end July	Bordeaux mixture made with 8 lb. copper sulphate 12 lb. quick lime ¼ lb. wetter	Black Currant Leaf Spot

* Flower buds on raceme unopened and clustered.

Specification of Materials.

For tar oil, tar oil-petroleum and wetters see apple.

Alternative Spray Materials.

18 lb. high grade hydrated lime may be substituted for 12 lb. quick lime.

Copper-lime dust may be used for application 3.

Supplementary Control Measures.

Reversion can be materially checked by planting only material from a disease free source.

Modifications for Pest and Disease Intensity.

The combined wash of tar oil-petroleum (1a) is essential when capsid bugs are present as pests.

Modifications of Programme for Varieties.

The post-cropping application of Bordeaux mixture is specially desirable on the Baldwin and Boskoop varieties which are highly susceptible to leaf spot (*Pseudopeziza ribis*). Varieties belonging to the Edina group, *e.g.* Victoria, Monarch, Goliath, are subject to sulphur injury, particularly if frost follows or coincides with the application. Not more than 4 per cent. concentration of lime sulphur can be safely applied to these varieties. Davison's Eight is very sensitive and it is not safe to apply lime sulphur to this variety at a concentration above 1 per cent.

References :—4, 8, 15, 16.

VI.—RED AND WHITE CURRANTS.

A programme similar to that for black currants is recommended. The concentration of lime sulphur should be reduced to 4 per cent.

VII.—GOOSEBERRY.

	Stage.	*Approximate date of spraying.*	*Material per 100 gallons water.*	*Pests and Diseases Controlled.*
1	Dormant	Dec.-Feb.	4–7½ gall. tar oil emulsion	Aphides
2	Before bud-burst	Early to mid February	10–12 gall. tar oil-petroleum wash	Aphides Capsids Winter Moth Gooseberry Red Spider
3	Fruit-setting	Late April	Sulphur dust	American Mildew
4	3 weeks after fruit setting	Mid May	Sulphur dust	American Mildew
or 4a	End May	End May	Derris (see under) ½ lb. wetter 1 gall. lime sulphur	Gooseberry Sawfly (1st brood) American Mildew
5	End June	End June—early July	Derris (see under) ½ lb. wetter	Gooseberry Sawfly (2nd brood)

Specification of Materials.

For tar oils and tar oil-petroleum washes and wetter see apple. The concentration of the Derris wash should be adjusted to 0.002 per cent. crystalline rotenone.

Modifications for Disease and Pest Intensity.

Winter washing with tar oil emulsion does not in all seasons provide a control of Gooseberry Red Spider (*Bryobia ribis*). An infestation may be controlled by the application in April of 1 per cent. concentration of a white oil emulsion.

If Sawfly is absent, sprays 4a and 5 can be omitted. In some seasons it may be necessary to control a third brood by the application at the end of August of a Derris or lead arsenate wash. It should be noted that gooseberries are often infested by Capsid when interplanted among apples.

The late application of a tar oil wash frequently checks bud damage by birds.

Modifications of Programme for Varieties.

Many dessert varieties, *e.g.* Yellow Rough, Early Golden Drop and Leveller are damaged by sulphur washes and dusts and should be sprayed with washing soda and soap (18 lb. soda and 10 lb. soap per 100 gall.) as a means of controlling American Mildew.

References :—4, 8, 15.

VIII.—RASPBERRY.

	Stage.	*Approximate date of spraying.*	*Material per* 100 *gallons water.*	*Pests and Diseases Controlled.*
1	Just before bud burst	From mid March*	4–7½ gall. tar oil emulsion	Raspberry Moth Aphides
2	Full blossom	Early June	Derris dust	Adults of Raspberry Beetle
3	2–3 weeks after petal-fall	Mid to end of June	Derris (see under) ½ lb. wetter or Derris dust	Larvae of Raspberry Beetle

* Also to the soil. See note on modification for pest intensity.

Specification of Materials.

For tar oil emulsion and wetter see apple ; for Derris see plum.

The Derris dust should contain not less than 0.18 per cent., and the wash not less than 0.004 per cent. crystalline rotenone. Many samples of Derris root contain 1.5 per cent. crystalline rotenone, and with a root of this concentration it is necessary to use 2½ lb. Derris root per 100 gallons wash. The application after petal fall is the more important, and a wash is preferable to a dust as it also provides a control of Aphides.

Modifications for Pest and Disease Intensity.

If Aphides are a pest in the bed and Raspberry Moth is absent, it is advisable to spray in early February instead of mid-March with a tar oil emulsion. Frequently winter washing may be omitted.

Raspberry Moth can be checked by the very liberal application of a tar oil emulsion to the soil around the crowns and adjacent to the rows of raspberries. Some damage to the plants may result but it is insignificant compared to the injury caused by the pest.

In some seasons Raspberry Beetle emerges early and causes appreciable flower-bud injuries, and when this occurs it is advisable to dust twice during the flowering period.

References :—2, 3.

IX.—LOGANBERRY.

A programme similar to that for raspberry is recommended.

X.—BLACKBERRY.

A programme similar to that for raspberry is recommended. Blackberries are subject to Aphid infestation and therefore a tar oil winter wash should be applied in each season, preferably in early February, but in mid-March if Raspberry Moth is present (see raspberry).

Two applications of a Derris dust or wash should be applied after petal fall on account of the long flowering period, the first at the period recommended for raspberries and a second two weeks later. The wash is preferable to the dust, as it also provides a control of Aphides.

XI.—STRAWBERRY.

	Stage and approximate date of spraying.	*Materials per* 100 *gallons water.*	*Pests and Diseases Controlled.*
1	Obvious crown development in March to early April	1½ gall. lime sulphur 1 lb. wetter 6 oz. nicotine	Strawberry Aphid Greenhouse Red Spider Mildew
2	Before flowering in mid May	do.	do.
3	After picking of fruit or de-blossoming	do.	do.
4	Mid July to mid August	do.	do.

Specification of Materials.

For white oil emulsion see apple.

Alternative Spray Materials.

White oil emulsion at 1 per cent. concentration may be substituted for the lime sulphur and the wetter in spray 4. The oil emulsion provides a high control of Red Spider eggs. A combined wash of lime sulphur and oil emulsion is not recommended.

Supplementary Control Measures.

Strawberry beds should be established only from runners obtained from hot-water treated parents. The hot water treatment is the only method of ensuring a control of Tarsonemid Mite. The method consists of immersing runners for twenty minutes in hot water maintained at 110°F. It should be noted that the temperature of the water must be uniformly maintained in the tank, as a momentary rise over 112°F will cause considerable loss of plants.

Runners selected from hot water treated parent plants should be dipped into either the lime sulphur-nicotine wash or nicotine-white oil emulsion (as recommended above) before planting out.

Burning off the dead leaves and straw in autumn is a valuable means of reducing Red Spider infestations.

Modifications for Pest and Disease Intensity.

The spray programme recommended above is intended as a routine procedure. In some circumstances nicotine-sulphur dusts may be substituted but with much less satisfactory results.

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THE CONTROL OF THE INSECT PESTS OF NURSERY FRUIT STOCK.

By **H. G. H. KEARNS** and **E. UMPLEBY.**

An essential feature in the production of high grade nursery stock is that it should be grown under conditions which allow of uninterrupted, steady growth. In practice, this is frequently not achieved owing to the inefficient control measures taken against insect pests and considerable losses result.

Young stock are characterised by the presence of vigorous, growing tissues which are particularly subject to insect attack. Biting and sucking injuries result in the development of malformations which may materially interfere with the shape and vigour of the future plant. Each class of fruit has its own particular assemblage of insect pests and thus it is impossible to adopt any simple standardised method for the control of pests on all nursery fruit plants. Several of the spray programmes (1) recommended for the pests of established fruit plantations are, in part, applicable to nursery stock but, in view of the very high value of the latter and the serious consequences of insect attack, it is profitable to adopt even more thorough control measures than in the former case.

The recommendations in this article are based on observations made on material propagated in the nurseries of Long Ashton Research Station and extending over a number of years. The crops include apple, pear, plum, currants, gooseberry, raspberry, loganberry, blackberry and strawberry.

The observations have emphasised the fundamental importance of insect pests in nursery practice. They have shown, in particular, that whilst in the case of established fruit crops, it is a usual practice to apply control measures when the intensity of the pest attack justifies the expenditure, in the case of nursery stock it is essential to anticipate insect attacks, the best procedure being to carry out routine spray programmes of a preventative nature even when pests are not in evidence.

In the notes which follow the major pests of the various classes of fruits are listed and programmes for control are given, together with information relating to important points concerning particular pests, insecticides, etc.

PESTS AND PROGRAMMES FOR VARIOUS CLASSES OF NURSERY FRUIT STOCKS.

APPLES.

Major Pests.

Permanent Apple Aphid	*Aphis pomi.*
Blue Bug	*Anuraphis roseus.*
Woolly Aphid	*Eriosoma lanigerum.*
(Occasionally other species of Aphides.)	
Apple Capsid	*Plesiocoris rugicollis.*
Green Capsid	*Lygus pabulinus.*
" Caterpillar "	*Cheimatobia brumata.* *Aniospteryx aescularia.*
Red Spider	*Oligonychus ulmi.*
Red Bud Borer	*Thomasiniana oculiperda.*
Clay Coloured Weevil	*Otiorrhynchus singularis.*
Leaf Eating Weevils	*Phyllobius pyri* and *oblongus.*

Programme.

Stage.	*Treatment.*	*Pest Controlled.*
Stool stock	Before planting out Hot water treatment*	Woolly Aphid Aphides
Budding	*Immediately* after tying rub over bass with vaseline	Red Bud Borer
Grafts	Select from trees sprayed with tar oil emulsion	Aphides
Stocks ready for budding and grafting	Spray with 4–7½ per cent. tar oil emulsion. Mid Dec.—mid Mar.	Aphides
Budded and grafted stocks	ditto	ditto
Grafted stocks mid April to end May	Paint grafts with Derris-arsenate mixture	Weevils
End May	1½ gall. white oil emulsion 8 oz. nicotine 100 gall. water	Woolly Aphid Other Aphides Capsids Red Spider
3rd week June	ditto	ditto
August (if necessary)	ditto	ditto
Trees prior to planting out in permanent quarters	Hot water treatment*	Woolly Aphid Other Aphides

* Or dip into 4–7½ per cent. tar oil emulsion. Hot water treatment is preferable.

Notes.

Red Bud Borer (5), although a serious pest, only occurs in certain nurseries and in many nurseries the control treatment may be omitted.

Tar oil emulsion must contain not less than 2.5 per cent. high-boiling, neutral tar oil soluble in dimethyl sulphate (4) to ensure aphid and sucker control.

Caterpillar is generally not a serious pest of apple stocks, but in wooded districts attacks may be appreciable. If attacks are consistently severe the tar oil emulsion concentration should be increased to contain 5 per cent. high-boiling oils. An alternative method of control would be the application of a lead arsenate wash at the rate of 2 lbs. of powder per 100 gallons water during the first week in May or as soon as the foliage damage is evident but before it is appreciable.

Capsid infestations are not infrequent and they must be controlled as they materially interfere with the sale of the trees. Frequently the infestations can be traced to other host plants, particularly currants and gooseberries. If the attacks are very slight the post blossom washes given in the programme will provide a control, but if an infestation is appreciable it is necessary to spray the trees at the end of February with a combined tar oil-petroleum wash. The wash must contain not less than 2.5 per cent. tar oil as defined above and 5.0 per cent. high-boiling petroleum oil. Other host plants must be sprayed with the same wash. This wash replaces the tar oil wash required for aphid and caterpillar control.

The hot water treatment consists of immersing the stools and trees into hot water maintained at 110°F for 30 minutes. If, for any reasons, this treatment cannot be carried out, the stools and trees should be dipped into a 4-7½ per cent. tar oil emulsion. It is essential that the earth is removed from the roots of the trees before treatment. The dipped trees should be arranged so that quick drying of the wash occurs. The trees prior to despatch from the nursery can be heeled into the soil.

Grafts can be effectively protected from weevil injury by liberally painting them with a mixture consisting of 1 lb. Derris or Barbasco ground root (not less than 1.5 per cent. crystalline rotenone), 2 lbs. lead arsenate powder or 4 lbs. paste or 2 quarts colloidal and 4 ozs. size. The Derris and arsenate should be mixed with water to a consistency of thick cream and to this mixture the size added (previously soaked in 1 pint warm water). The grafts should be painted just prior to bud burst and in some seasons a second application may be necessary as the Leaf Weevils feed over a long period.

Under no circumstances should neat paraffin (kerosene) be applied to nursery trees as a means of controlling Woolly Aphid. Methylated spirit may be used, but at times it results in injury (2, 3). If apple scab infestations on the leaves and shoots are serious, 1 gallon of lime sulphur may be added to the white oil emulsion wash applied at the end of May and third week in June. If the variety is subject to sulphur injury lime sulphur may be replaced by Bordeaux mixture. The oil in both cases must be emulsified with sulphite lye.

PEAR.

Major Pests.

Caterpillar	*C. brumata.* *A. aescularia.*
Aphides	*A. roseus.*
Blister Mite	*Eriophyes pyri.*
Pear Slugworm	*Eriocampa limacinia.*
Graft Weevils	*O. singularis.* *P. oblongus* and *pyri.*

Programme.

Stage.	*Treatment.*	*Pest Controlled.*
Grafted stocks	4–7½ per cent. tar oil emulsion	Aphides
End February	5–7 per cent. petroleum emulsion or 10 per cent. tar oil-petroleum emulsion	Winter Moth Blister Mite Aphides Winter Moth Blister Mite
Mid May or earlier	Derris-arsenate mixture	Weevils on grafts
Mid June	2 lb. lead arsenate ¼ lb. wetter* 100 gall. water	Pear Slugworm
Mid July	ditto	ditto

* Agral 2, Lethalate Wetting Preparation or Sulphonated Lorol.

Notes.

For tar oil and tar oil-petroleum emulsions and Derris-arsenate mixture see apple. The petroleum emulsion should contain not less than 5.0 per cent. high-boiling petroleum oil. If Blister Mite and Caterpillar are of little importance only a tar oil emulsion need be applied. If Aphides, Blister Mite and Caterpillar are serious pests the tar and petroleum oils may be applied separately or as a combined wash.

Washes for the control of Slugworm need not be applied until the young larvae are seen. It should be noted that this pest can do extensive foliage injuries in a few days and thus early control is essential.

PLUM.

Major Pests.

Leaf Curling Aphid	*Anuraphis padi.*
Hop-Damson Aphid	*Phorodon humuli.*
Red Spider	*O. ulmi.*
Thrips	
Caterpillar	*C. brumata.* *A. aescularia.*
Graft Weevils	*O. singularis.* *P. oblongus* and *pyri.*

Programme.

Stage.	*Treatment.*	*Pest Controlled.*
Grafts	Select from trees sprayed with tar oil emulsion	Aphides
Stocks and grafted trees	4–7½ per cent. tar oil emulsion Mid Dec.—end Jan.	Aphides
1st week May	2 lb. lead arsenate powder ¼ lb. wetter 100 gall. water	Caterpillar
Mid April to Mid May	Derris-arsenate mixture	Graft weevils
End May	1 gall. white oil emulsion	Red Spider

Notes.

For tar oil emulsion and Derris-arsenate mixture see apple. Nursery plum stocks cannot be grease banded and therefore a lead arsenate wash should be applied in early May for the control of caterpillar. Thrips at times entirely ruin grafts, especially those of damsons. Attacks may be controlled by the application of a wash containing one gallon white oil emulsion and 8 oz. nicotine per 100 gall. water.

CURRANTS.

Major Pests.

Blister Aphid	*Capitophorus ribis.*
Leaf Curling Aphid	*Amphorophora cosmopolitana.*
Big Bud Mite	*Eriophyes ribis.*
Apple Capsid	*P. rugicollis.*
Green Capsid	*L. pabulinus.*

Programme.

Stage.	*Treatment.*	*Pest Controlled.*
Unrooted and rooted cuttings	Dip into 10 per cent. tar oil-petroleum emulsion before planting out mid Dec.—mid Feb.	Aphides Capsids
Terminal leaves shilling size stage	4–8 gall. lime sulphur ¼ lb. wetter 100 gall. water	Big Bud Mite

Notes.

For tar-petroleum emulsion see apple and for wetter see pear. The cuttings after dipping should be allowed to dry quickly. On no account should they be kept wet in bundles.

Some varieties of currants are subject to injury by high concentrations of lime sulphur. Edina and related varieties can only be sprayed with a 4 per cent. concentration. Davison's Eight may be damaged by concentrations above 1 per cent. On this variety the application of a white oil emulsion at 7½ per cent. (5 per cent. oil) concentration is worthy of trial. The emulsion should be applied before the flowers open.

Occasionally very severe damage is caused by Raspberry Weevil (*O. singularis*) to the shoots in early spring. For control see raspberry.

GOOSEBERRY.

Major Pests.

Gooseberry Aphid	*Aphis grossulariae.*
Gooseberry Root Aphid	*Eriosoma ulmi.*
Gooseberry Red Spider	*Bryobia ribis.*
Gooseberry Sawfly	*Pteronus ribesii.*
Apple Capsid	*P. rugicollis.*
Green Capsid	*L. pabulinus.*

Programme.

Stage.	*Treatment.*	*Pest Controlled.*
Unrooted and rooted cuttings	Dip into 10 per cent. tar oil-petroleum emulsion before planting out February	Aphides Capsids Red Spider
Cuttings in the ground	ditto	ditto
Mid-end May	Derris dust	Sawfly
Mid-end June	ditto	ditto

Notes.

For tar oil-petroleum wash see apple. The cuttings after dipping must be allowed to dry quickly and on no account kept wet in bundles for any length of time.

The Derris dust must be used at a concentration that represents not less than 0.18 per cent. crystalline rotenone. A Derris, nicotine or lead arsenate wash may be substituted for the dust.

Mildew may be checked and sawfly controlled by substituting a 3.0 per cent. nicotine-sulphur dust. Certain varieties, such as Keepsake, Lancashire Lad and Careless, are subject to sulphur injury. Golden Drop is damaged by all forms of sulphur.

RASPBERRY, LOGANBERRY AND BLACKBERRY.

Major Pests.

Raspberry Aphid	*Amphorophora rubi.*
Raspberry Weevil	*O. singularis.*

Programme.

Stage.	*Treatment.*	*Pest Controlled.*
January	4–7½ per cent. tar oil emulsion	Aphid

Notes.

Aphides, particularly on the raspberry, should be controlled as completely as possible, as it has been shown that these insects are vectors of mosaic disease. In some localities, particularly wooded ones, Raspberry Weevils sometimes appear in large numbers and attack the bark of the canes. The attack can be checked by spraying the shoots with a high concentration of a Derris and lead arsenate wash. The wash should consist of 5 lbs. Derris or Barbasco root, 10 lbs. lead arsenate powder or its equivalent, and 20 oz. size per 100 gallons water.

In addition to spraying it may be worth applying a Derris dust late in the evening.

The attack is usually confined to a short period.

STRAWBERRY.

Major Pests.

Strawberry Aphid	*Capitophorus fragaefolii.*
Tarsonemid Mite	*Tarsonemus fragariae.*
Greenhouse Red Spider	*Tetranychus telarius.*

Programme.

Stage.	*Treatment.*	*Pest Controlled.*
September	Hot water treatment of parent runners	Aphid Mite Spider
Just before flowering	Spray 1 gall. lime sulphur 1 lb. wetter 6–8 oz. nicotine 100 gall. water	Aphid Spider
After de-blossoming	ditto	ditto
September	Dip runners from hot water treated parent plants in 1 gall. white oil emulsion 6 oz. nicotine 100 gall. water	ditto
Nov.—March	Burn off old leaves and rubbish on parent bed	Spider

Notes.

For wetter see pear.

The hot water treatment consists of immersing the runners for twenty minutes in water maintained at 110°F.

The parent bed can be used for the production of runners for more than one season provided it is rogued and remains free from Mite infestation.

SPECIAL NOTES.

Soil Pests.

There are a number of soil insect pests which are common to currants, gooseberry, raspberry, loganberry, blackberry and strawberry nursery stock. The more important are the larvae of the Chafer Beetles, Noctuid Moths, Leather Jackets (Tipulidae) and Weevils. Many of these can be controlled or materially checked by a combination of a soil dressing and poison bait. As soon as an attack is observed the soil should be dressed with whizzed naphthalene at the rate of 4 ozs. per square yard. At the same time a Paris Green bran bait should be thinly broadcast over the soil. The bait is prepared by shaking ¼ lb. of Paris Green with 7 lbs. dry bran. When required the mixture is just moistened with weak sugar solution. The best results are obtained when it is applied on damp, warm evenings, several applications usually being necessary.

Methods of Spraying Nursery Stock.

Nursery stock is much more difficult to spray than trees in established plantations. The dense planting of many nursery crops materially interferes with the application of washes, and intelligent and careful spraying is essential to ensure a satisfactory control of the pests. Both sides of the trees and both surfaces of the leaves must be covered by the wash, and this is best attained by the use of an inclined nozzle on a short lance or gun. A pressure of about 200 lbs. per square inch is sufficient. Lances or spray guns with straight nozzles are not suitable.

A small power outfit, preferably self-propelled, is best suited for nursery work. The outfit should be worked from conveniently placed headlands and the wash conveyed to the operators by means of reasonable lengths of hose or overground mains.

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COMBINED WASHES.

PROGRESS REPORT.—III.

By H. G. H. KEARNS, R. W. MARSH and H. MARTIN.

I. INTRODUCTION.

Spray trials of the 1936 season were more productive of results than those of the 1935 season when late frosts caused a total loss of crop. Weather conditions early in the year were such that spray damage was unusually prevalent, a feature reflected in the abnormally high number of enquiries received from other parts of the country. Further, conditions were favourable to the development of apple scab and information upon fungicidal efficiency was obtained from spray trials upon the Station plantations, trials which in previous years had given no results because of the scarcity of scabbed fruit on trees receiving no fungicide.

The main lines of investigation concerned the use of petroleum oils as supplements in combined washes ; firstly, the effect of the addition of oil upon the fungicidal and phytocidal properties of lime sulphur combinations and, secondly, the value of the oil as a penetrant and solvent in rotenone-containing sprays.

II. THE FUNGICIDAL AND PHYTOCIDAL PROPERTIES OF LIME SULPHUR—PETROLEUM OIL SPRAYS.

A. The use of Highly-refined Petroleum Oil.

In the 1934 Report (2), reference is made to the recommendations prevalent in the United States that petroleum oil sprays should not be applied shortly before or after a lime sulphur wash because of a liability to cause damage. At Long Ashton in 1934 and 1935, however, it was shown that no abnormal spray damage followed the simultaneous application of petroleum oil with lime sulphur, provided that a highly refined (Grade G) oil and an inert emulsifier such as sulphite lye was used. It became necessary therefore to determine whether, provided these two precautions were observed, the combined wash could be applied safely under the weather conditions prevailing in other parts of the country. For this purpose advantage was taken of the generous offer of various collaborators, in particular, Messrs. M. H. Moore and H. B. S. Montgomery, of the East Malling Research Station, Mr. W. F. Cheal, Horticultural Superintendent for the County Council of the Isle of Ely, and Mr. E. W. Hobbis, of the Department of Agricultural Education, Worcester, to all of whom batches of the sulphite lye-petroleum oil emulsion were sent. This product contained 66.7 per cent. by volume petroleum oil (L6) of characteristics given in Table I. the remainder being 20 per cent. sulphite lye (60°Tw).

TABLE I.

CHARACTERISTICS OF OILS EMPLOYED.

	P.21	P.22	L.6	P.4d.
Sp. Gr. (60° F.)	0.899	0.886	0.864	0.898
Viscosity—Redwood 1 at 70°F...	173	211	127	167 sec.
Boiling range :—				
90% by vol. distils above ..	369	374	323	348° C.
50% ,, ,, ,, ,, ..	385	391	357	378° C.
20% ,, ,, ,, ,, ..	—	—	384	—
Unsulphonated residue % by vol.	77.5	78	98	74

(i) East Malling.

An account of the trial carried out by Messrs. Moore and Montgomery has been published in the East Malling Annual Report (5). The petroleum oil emulsion was added at 7.5 per cent. to the " green bud " lime sulphur-lead arsenate spray, at 4.5 per cent. to the " pink-bud " lime sulphur-lead arsenate spray and at 1.5 per cent. to both the " petal fall " and " three weeks " lime sulphur applied to Cox's Orange Pippin trees. Subsequent to this somewhat drastic spray programme the trees receiving the petroleum oil sprays were conspicuous by their sparse foliage, especially those on the more weakly-growing rootstocks (M. I, III, IX). Owing to the loss of crop by frost no conclusion was reached upon the influence of the addition of the oil emulsion upon fungicidal efficiency.

(ii) Isle of Ely.

The trials carried out by Mr. Cheal were upon the varieties Bramley's Seedling and Newton Wonder, and we are indebted to him for the following notes :—

The Bramley trees received no fungicide at the green flower stage, the spray programme being :—

At pink bud (4th May) 1 in 30 lime sulphur with and without 4.5 per cent. petroleum oil emulsion.

At petal fall (25th May) and "three weeks" (12th June) 1 in 100 lime sulphur with and without 1.5 per cent. petroleum oil emulsion.

Apart from slight scorching of the leaves by the first application, no spray damage was observed. Although it was at first thought that scab was more severe upon the trees receiving petroleum oil, counts assembled in Table II failed to show any difference in scab control.

TABLE II.

PER CENT. SCABBED FRUIT (ISLE OF ELY).

	No. of Fruits.	*Percentage Fruit.* Clean.	"Pin Spot" Scab.	Badly Scabbed.
With petroleum oil	940	58.8	35.2	5.8
	276	52.5	36.9	10.5
No petroleum oil	364	64.8	23.6	11.5
	325	42.7	42.7	14.4

The Newton trees received the routine green flower, pink bud, petal fall and "three weeks" lime sulphur sprays, with and without the petroleum oil emulsion at the following strengths 7.5, 4.5, 1.5, 1.5 per cent. at the four stages respectively. The foliage showed heavy scorching at the green flower stage. The post-blossom applications were all non-phytocidal and no differences could be observed in the yield of crop.

(iii) Perdiswell, Worcestershire.

The trial at this centre was carried out on 288 trees, the varieties represented being as follows :—

Advance, Alderman, Annie Elizabeth, Beeley Pippin, Blenheim Orange, Bramley, Bushy Grove, Charles Ross, Col. Vaughan, Cox's Orange Pippin, Crawley Beauty, Edward VII, Ellison's Orange, Epicure, Exquisite, Feltham Beauty, Grenadier, James Grieve, King George V, King of the Pippins, King of Tompkins County, Lord Lambourne, Laxton's Superb, Lord Hindlip, Long Ashton A.S.A.22, Miller's Seedling, Norfolk Royal, Ontario, Red James Grieve, Renown, Rival, Sir John Thornycroft, Snow, Wealthy, Winter Banana, Worcester Pearmain.

The trees of each variety were divided into three groups, A, B and C, which respectively received the following treatments :—

A. Sprayed at bud-burst (April 6) with 7½ per cent. white oil emulsion (5 per cent. Grade G oil emulsified with sulphite lye).

Sprayed at green-flower stage (April 28) with 3½ per cent. lime sulphur.

B. Sprayed (April 28) with a combined wash of 7½ per cent. white oil emulsion and 3½ per cent. lime sulphur.

C. Unsprayed at bud-burst and green flower stages.

Observations were made at intervals during the season, but the only damage noted was on the trees of the variety Charles Ross sprayed with the combined petroleum-lime sulphur wash. Certain branches of these trees when examined at the petal fall stage showed slight scorching of the flower trusses. At the time of harvesting no cropping differences resulting from the spraying treatments were noted. Capsid infestation was nowhere sufficient for a comparison of insecticidal effects.

(iv) Pebworth, Worcestershire.

A combined wash of 3 per cent. lime sulphur with 7½ per cent. white oil emulsion (5 per cent. Grade G oil emulsified with sulphite lye), was applied at this centre on April 23rd to 12 Worcester Pearmain and 8 Lord Grosvenor trees. A similar number were left unsprayed. The wash was applied with inadequate spraying equipment and the cover obtained was somewhat unsatisfactory. No damage was caused and a count made at picking time of the entire crop of the Worcester trees gave the following result :—

	Sprayed.	*Control.*
Number of fruits	885	548
Percentage marked by capsid	13.3	72.1

A marked reduction of capsid infestation was thus obtained in spite of defective spraying.

(v) Malvern, Worcestershire.

At this centre the comparison made at Perdiswell was repeated, the varieties sprayed with the combined oil-lime sulphur wash being Cox and Bramley (at the early green flower stage) and Derby and Newton (at the "burst" stage). Tests were also carried out at the same time with a proprietary emulsion of Grade G oil (emulsified with sulphite lye) and mixed with lime sulphur. Approximately 35 well-grown trees of each variety were sprayed on April 17 with each of the petroleum-lime sulphur washes, the oils being used at 5 per cent. and the lime sulphur at 3½ per cent. Neither of the applications caused injury and the control of capsid was satisfactory with both trestments.

(vi) Lyonshall, Herefordshire.

The orchard at this centre, described in the previous Progress Report, was again utilised for a trial of an oil-lime sulphur spray in 1936. The wash as used at Perdiswell was applied on April 23 to the varieties Derby and Rival: no injury appeared on either variety but the infestation of scab and capsid was insufficient to supply information on the value of the application.

(vii) Long Ashton (Plot 11).

This plot consists of 17 rows each of twenty trees planted in 1923. Each row running from north to south is of a single variety, the commercial varieties included being Bramley, Worcester, Newton, Grenadier, Blenheim, Ross, Ellison, Bath, Lambourne, Lane, Superb, Rival, Cox and Allington. The various spray treatments were applied to rows running from east to west across the variety rows and included :

	At Green Flower Stage 27th April.	*At Pink Stage 5th May.*	*At Petal Fall Stage 26th May.*
Rows 3, 4, 13 & 14	Lime Sulphur (1 in 30)	Lime Sulphur (1 in 30)	Lime Sulphur (1 in 100)
Rows 5, 6, 15 & 16	Lime Sulphur (1 in 30) plus 0.05% Sulphonated Lorol.	Lime Sulphur (1 in 30) plus 0.05% Sulphonated Lorol.	Lime Sulphur (1 in 100) plus 0.05% Sulphonated Lorol.
Rows 7, 8, 17 & 18	Lime Sulphur (1 in 30) plus 7.5% petroleum oil emulsion.	Lime Sulphur (1 in 30) plus 4.5% petroleum oil emulsion.	Lime Sulphur (1 in 100) plus 1% petroleum oil emulsion.

The sprays were applied in liberal amounts by means of a 9 H.P. Swinson power sprayer operating two spray guns. The trees in rows 1, 2, 11, 12, 19 and 20 were left unsprayed as controls.

Slight scorching followed the pre-blossom treatments, but this was not accentuated by the addition of either the oil or the sulphonated lorol. After the post blossom spraying no damage was observed. Scab developed lightly upon the unsprayed trees, and at fruit picking the crop was graded for scab with the results given in Table III. Fruit bearing scab lesions of area greater than three circles of diameter 1 m.m. were counted as scabbed, cracked unsaleable fruit being separately counted.

On four varieties the figures showed little difference in the results of the three spraying programmes, but on the varieties Worcester and Bramley there was an indication that the incorporation of the petroleum oil had tended to reduce the extent of scab control by the lime sulphur.

In conjunction with the result of the Isle of Ely trial and with the conclusions of laboratory experiments, this evidence justified the conclusion that a petroleum oil-sulphite lye emulsion when used as a lime sulphur supplement, does not enhance fungicidal properties, a conclusion in interesting contradistinction to that derived from field trials of glyceride oil-Bordeaux combinations. In the latter it has been shown that the addition of oil improves the retention and tenacity of the Bordeaux deposit to an extent such that it is possible to reduce to half the copper sulphate content of the Bordeaux mixture without reducing fungicidal efficiency.

Because of the absence of the "sticker" effect it becomes questionable whether the use of highly refined petroleum oils with lime sulphur is necessary when the oil serves no useful acaricidal or ovicidal purpose nor is required as a penetrant for insecticidal purposes. One such case is in the pink bud lime sulphur spray from which it is proposed in future to omit the petroleum oil emulsion. To overcome the phytocidal tendencies of lime sulphur when applied in heavy amount it may be advisable to add, in place of the petroleum oil emulsion, a water-soluble spreader in limited amount just sufficient to secure effective wetting of the foliage and to prevent the localised formation of large spots of heavy spray deposit.

TABLE III.

PER CENT. SCABBED FRUIT (LONG ASHTON).

Variety.	*Unsprayed.*				*Lime Sulphur only.*				*Lime Sulphur—Sulphonated Lorol.*				*Lime Sulphur—Petroleum Oil Emulsion.*			
	Mean No. of fruits per tree.	*Mean percentage per tree.*			*Mean No. of fruits per tree.*	*Mean percentage per tree.*			*Mean No. of fruits per tree.*	*Mean percentage per tree.*			*Mean No. of fruits per tree.*	*Mean percentage per tree.*		
		Clean.	*Scabbed.*	*Cracked.*		*Clean.*	*Scabbed.*	*Cracked.*		*Clean.*	*Scabbed.*	*Cracked.*		*Clean.*	*Scabbed.*	*Cracked.*
Allington ..	223	79.7	19.0	1.3	346	96.9	3.1	0.0	51	98.3	1.7	0.0	239	97.9	2.0	0.1
Bramley ..	353	80.6	17.3	2.1	239	97.9	2.0	0.1	44	99.1	0.9	0.0	532	79.5	20.1	0.1
Cox	142	75.3	21.9	2.8	314	98.6	1.4	0.0	215	98.4	1.6	0.0	182	97.4	2.6	0.0
Lane	99	82.5	15.4	2.1	222	99.0	1.0	0.0	116	99.6	0.4	0.0	161	97.2	2.8	0.0
Newton ..	73	86.3	12.8	0.9	74	98.3	1.7	0.0	45	96.8	3.2	0.0	118	97.3	2.6	0.1
Worcester ..	284	67.7	30.2	2.1	228	80.7	18.1	1.2	388	84.6	15.0	0.4	557	77.1	22.0	0.9

B. The Use of Semi-refined Petroleum Oils.

A serious commercial disadvantage of the use of highly-refined petroleum oils of the type so far used in the investigations upon combined washes is their expense. Oils less highly-refined and consequently cheaper are known to be more apt to cause foliage and bud burn. but it was considered worth while to determine how serious is this damage. when the wash is applied at the pre-blossom stages.

Up to the past year the refined petroleum oils obtainable in this country have all been acid-refined and, in general, three grades of refinement are available: firstly, the so-called white oils of unsulphonated residue greater than about 96 per cent. costing, in barrel quantities, about 2/9 per gallon; secondly, the half-white oils of unsulphonated residue 80-90 per cent. and costing in similar quantities about 2/3 per gallon; thirdly, semi-refined spindle oils of unsulphonated residue 60-80 per cent., costing 1/- to 1/6 per gallon in bulk lots. The substitution of half-white for white oils will, as seen from these figures, lessen cost slightly but not sufficiently. and it was therefore decided. at first, to examine the effects of the use of the spindle oil grade, of which three representative oils were used. The characteristics of these oils are given in Table I. P4d, costing 1/- per gallon, was of the stock used in the preparation of winter washes. The remaining two oils P21 and P22 had somewhat greater unsulphonated residues. each costing about 1/6 per gallon. For comparative purposes a highly-refined oil (L6) was included.

(i) Upon Apples:

(*a*) *Long Ashton.* (Plot 7c). A block of 100 large 15-year-old bush trees was divided up into 10 rows, so that each row contained an equal number of the same varieties, of which the principal were Annie Elizabeth, Early Victoria, Newton Wonder, Allington Pippin, Lord Hindlip and Coronation. These varieties were subjected to the following treatments, the emulsions being applied at a concentration of 5.0 per cent. oil and the lime sulphur at 3.5 per cent. by volume.

1. P.21 plus lime sulphur (2 rows).
2. L.6 plus lime sulphur (2 rows).
3. Lime sulphur (1 row).
4. P.22 plus lime sulphur (1 row).
5. Unsprayed controls (2 rows).
6. L.6 alone (1 row).
7. P4d plus lime sulphur.

The washes were applied on May 1st, 1936, at the rate of 5 gallons per tree, when the varieties Annie Elizabeth, Newton Wonder, Allington Pippin were in the green flower stage and the varieties Early Victoria (in part), Hindlip and Coronation in the pink bud stage.

Observations were made at regular intervals during the season. It was evident within a week of the application of the washes that very severe injury had been caused to the foliage and flower buds by the least refined oil, P4d. Very considerable bud injury was caused by the oils P.21 and P.22, the damage being most obvious on the varieties sprayed in the " pink-bud " stage, whereas many of the buds in the greenflower stage escaped injury. The damaged buds and leaves eventually fell off the tree. A negligible amount of damage was noted on the trees sprayed with the refined oil L.6, applied alone and in combination with lime sulphur, and it was slightly less than that on the trees sprayed with lime sulphur only.

By June, the damage became less evident on account of the development of vegetative buds and, by the end of the summer, there was little evidence of the injury other than a reduction of crop on the injured trees. The injured trees of the variety Early Victoria produced a satisfactory crop, mainly because a number of the flower buds were backward and in the early " greenflower " stage at the time of spraying.

(*b*) *Long Ashton.* (Plot 14a). Two rows, each of 13 well-grown Bramley Seedling bush trees, were sprayed with the following emulsions at the " greenflower " stage on April 25th, 1936 :—

Row (1) 7½ per cent. emulsion (5.0 per cent. oil) P.21.
3.5 per cent. by volume lime sulphur.

Row (2) 7½ per cent. emulsion (5.0 per cent. oil) L.6.
3.5 per cent. by volume lime sulphur.

The only damage noted was caused by the less refined oil (P.21) and the amount was not as serious as experienced when applied to other varieties at the " pink-bud " stage (see above (a)). The chances of damage were considerably reduced by the paucity of blossom buds.

(ii) Upon Currants.

A plot of 1,062 black currant bushes of various varieties was divided into seven blocks in a manner such that the following treatments could be applied to equal numbers of each variety :—

1. Unsprayed.
2. P.21 plus lime sulphur.
3. P.21 alone.
4. Unsprayed.
5. L.6 plus lime sulphur.
6. L.6 alone.
7. Lime sulphur alone.

In each instance the oil emulsion was applied at a concentration of 7½ per cent. (5.0 per cent. oil) and 3.5 per cent. by volume of lime sulphur.

The washes were applied on April 6th, 1936, when the buds on the racemes were exposed but close together and the foliage was at the " two-shilling " stage.

Observations were made at regular intervals and by April 22nd it was obvious that the less refined oil P.21 alone and in combination with lime sulphur had caused a considerable check to the growth of foliage whilst the flower racemes were not normal. On May 28th it was evident that the retardation of leaf growth was very severe and the blossom was withering and falling off. The refined oil alone, and in combination with lime sulphur, caused some damage but not appreciably greater than that caused by the lime sulphur alone.

The crop weights are recorded in Table IV.

TABLE IV.

CROP WEIGHT (GRAMS) AS AVERAGE WEIGHT PER BUSH.

Variety.	*Baldwin.*	*Black Tony.*	*Westwick Choice.*	*Davisons Eight.*	*Blacksmith*	*Tinker.*
No. of bushes per treatment ..	45	18	9	9	9	9
P.21 + L.S. ..	376	780	210	590	1100	1100
P.21	432	460	180	450	1170	1060
L.6 + L.S. ..	820	1250	750	880	1300	1650
L.6	1300	570	2030	980	1460	1000
L.S.	470	630	1190	640	480	790
Control 1	1490	1320	1180	1090	1880	1600
,, 2	921	1330	620	1300	1800	1800

An analysis of these results indicates a decrease in crop weight in the following general order of treatment, which may vary according to the variety :—control, L.6 alone, L.6 plus lime sulphur, lime sulphur alone, P.21 plus lime sulphur, P.21 alone. The trial showed that an oil of the refinement of P.21 (unsulphonated residue = 77.5 per cent. by volume) could not be used with any safety on black currants. There is an indication that lime sulphur when used in conjunction with the emulsion L.6 causes less damage than the lime sulphur used alone.

III. HYDROCARBON OILS AS SUPPLEMENTS FOR ROTENONE-CONTAINING INSECTICIDES.

Investigations upon the utilization of Derris and related plant products as insecticides have been continued upon the lines indicated in the last report (3) and have been brought parallel to the work upon the use of penetrants in insecticidal washes. In previous field trials in connection with the latter subject, nicotine had generally been employed as the insecticide and differences in efficiency associated with differences in the penetrating properties of the spray supplements were not found. Thus in 1934 (2) no significant differences in the degree of apple sawfly control were obtained with lime sulphur-nicotine-spreader sprays in which five different water-soluble spreaders were employed. It was therefore decided to examine the effects of the substitution of the nicotine by a non-volatile insecticide for which purpose rotenone-containing materials were found suitable in trials reported last year.

A. Control of Apple Sawfly.

(i) Kemerton.

A plantation containing twenty rows of trees of the variety Charles Ross with intermediate rows of 14 years old bush Ellison and Cox were available for the purpose of this trial. Only the Ross trees were sufficiently infested with apple sawfly eggs to justify spraying. The plantation was accordingly divided into two blocks at right angles to the direction of the rows and within each block the position of rows receiving the following treatments was randomised :—

1. Lime sulphur (1% by vol.), sulphonated lorol (0.05%).
2. Nicotine (0.05%), lime sulphur (1%), sulphonated lorol (0.05%).
3. Derris root (0.25%), lime sulphur (1%), sulphonated lorol (0.05%).

4. Derris root (0.1%), lime sulphur (1%), sulphonated lorol (0.05%).
5. Barbasco root (0.1%), lime sulphur (1%), sulphonated lorol (0.05%).
6. Derris extract (0.016%), lime sulphur (1%), sulphonated lorol (0.05%).
7. Derris extract (0.016%), lime sulphur (1%), Agral 2 (0.05%)
8. Derris extract (0.016%), lime sulphur (1%), Gamma-sulphonates (0.05%).
9. Derris extract (0.016%), lime sulphur (1%), sulphite lye (0.75%).
10. Derris extract (0.016%), lime sulphur (1%), petroleum oil emulsion (1%).

The ground Derris root employed in sprays (3) and (4) yielded 10.5 per cent. ether extract from which approximately 1.0 per cent. (upon root) of rotenone was recovered by crystallization. The root used in spray (5) was purchased from importers under the name Barbasco root, and yielded 17.0 per cent. ether extract from which 5.6 per cent. (upon root) of rotenone was recovered by crystallization. The Derris extract was purchased as a resinous solid of 25 per cent. rotenone content, and on analysis by the Cahn and Boam method (1) 20.1 per cent. pure rotenone was recovered. It was accordingly used at a concentration based upon the calculation that 2.6 oz. of resin were equivalent to 1 lb. of the barbasco root.

For the preparation of the sprays the required weight of extract (2.6 oz.) was dissolved in 13 fl. oz. carbitol (diethylene glycol monoethyl ether), slight heating being necessary just before use, and the solution added to the concentrated spreader solution (*e.g.* 8 oz. sulphonated lorol or 1 gal. petroleum oil emulsion in 2 gals. water) with thorough agitation, the whole then being added to the bulk of the diluted lime sulphur in the spray tank.

Of the spreaders used, sulphonated lorol and Agral 2 were from bulk supply; the gamma-sulphonates (4) were supplied by oil refiners in the form of a 20 per cent. solution of the sodium salts. The sulphite lye used was the syrup (60°Tw), which also formed the emulsifier of the petroleum oil emulsion (66.7 per cent. Grade G oil).

Spraying was carried out upon May 29th and the observations relevant to sawfly infestation were as follows :—

May 26th. Petal fall completed.

May 29th. Majority of the eggs exposed within the calyx cup by the rupture of the calyx tissue. None of the eggs had hatched but were obviously near the end of their incubation period. Washes applied.

June 2nd. Majority of the eggs were hatching.

June 11th. Samples of fruitlets with egg scars were collected from all the plots for examination.

Results are recorded in Table V.

TABLE V.

LARVAL MORTALITY.

Treatment.	*Total No. of fruitlets examined with egg shells in calyx.*	*No. of living larvae.*	*No. of dead larvae.*	*Percentage of living larvae.*
Derris (0.25 %)–sulphonated lorol	57	33	24	57.2
Nicotine ,,	66	18	48	27.5
Barbasco ,,	83	24	59	29.0
Extract ,,	74	17	57	23.0
,, sulphite lye ..	83	49	34	59.0
,, Agral "2"	63	29	34	46.0
,, oil emulsion	81	7	72	8.6
,, Gamma sulphonates	—	—	—	—
Control	50	48	2	96.0

For the purpose of this examination only fruitlets with definite evidence that an egg had been laid in them were included in the examination. It should be noted that an appreciable number of fruitlets bore external egg scar marks, but eggs were not necessarily deposited in them.

The results of this examination suggested that the oil emulsion plus barbasco extract provided a much greater kill of the larvae than any of the other treatments. This conclusion was confirmed by the field counts made at a later date and recorded in Table VI.

For the estimation of the degree of sawfly control the numbers of total and sawfly-infested fruits per tree were counted upon July 3rd by four observers who each recorded two adjacent trees in each row in the two blocks. Fallen fruits were not included as trial counts showed no great difference in percentage infestation in the few fruitlets upon the ground and those upon the tree. Each pair of trees was considered as one unit for the statistical analysis of the results which are assembled in Table VI.

TABLE VI.

Number and Percentage Sawfly-infested Fruit.

Treatment.	*Insecticide.*	*Spreader.*	*Total Number of Fruits.*	*Mean Percentage Sawfly-infested.*
1	None.	Sulphonated lorol.	2111	65.3
2	Nicotine.	,, ,,	2220	16.7
3	Derris (0.25%)	,, ,,	3255	15.9
4	Derris (0.1%)	,, ,,	2829	39.8
5	Barbasco (0.1%)	,, ,,	2732	23.8
6	Derris extract	,, ,,	2822	24.2
7	,, ,,	Agral 2.	2562	23.9
8	,, ,,	Gamma-sulphonates	2478	34.0
9	,, ,,	Sulphite lye.	2804	39.2
10	,, ,,	Petroleum oil emulsion	1795	6.8
Significant difference (P=0.05)			750	12.72

From these results it may be concluded that, of the penetrants tested, sulphonated lorol and Agral 2 at 0.05 per cent. are superior to sulphite lye as supplements for Derris extract-lime sulphur combination for use against apple sawfly. The petroleum oil emulsion has proved superior to the water-soluble spreaders though, in view of the greater solubility of rotenone and related insecticides in petroleum oils than in water, this difference cannot be ascribed wholly to a better penetrant action. The total fruit counts show that upon the trees receiving the petroleum oil emulsion, the number of fruitlets is smaller. Additional evidence is required before this effect can be ascribed to the phytocidal action of the spray. Of the rotenone-containing insecticides, the Derris, poor in readily-crystallizable rotenone, has proved inferior to barbasco at a similar concentration though effective at the higher concentration generally used in practice. The laboratory estimate of the equivalent of the extract in terms of the root is confirmed in the field.

(ii) Long Ashton.

At Long Ashton a trial similar to that at Kemerton was carried out but on a less comprehensive scale on the variety Worcester Pearmain. The same materials and concentrations were used as in the Kemerton trial with the exception that acetone was employed instead of carbitol as the resin solvent. A block of 96 fifteen-year-old bush trees was divided into 8 equal rows. Each row of trees was subjected to a different treatment. The notes referring to the apple sawfly infestation are as follows :—

May 22nd.	Majority of the eggs unexposed and still covered by the calyx cup tissue.
	Washes applied under excellent spraying conditions.
May 26th.	Eggs commencing to hatch on the control trees.
May 28/29th.	Majority of the eggs hatched.

None of the washes provided a satisfactory control and there was little difference between the treatments. The failure of the rotenone resin to provide a control at this centre, whereas it was satisfactory, particularly in combination with an oil emulsion, at Kemerton is of considerable interest. The explanation most probably lies in the fact that the concentration of the crystalline rotenone of the resin was some 50 per cent. lower than that used in previous trials which had consistently given satisfactory results. The lower concentration of the toxic materials reduced the duration of effective toxicity, evidently in these trials by a period of at least three days. Thus at Kemerton the time interval between the application of the washes and egg hatch was four days, whereas at Long Ashton it was 6—7 days. In previous seasons a high concentration of crystalline rotenone had in all instances provided an effective duration of toxicity of at least seven days.

The results of these two trials suggested that rotenone-containing material is an effective insecticide for comparative studies on wetters and penetrants provided the concentration of rotenone is adequate to give an effective duration of toxicity over the period between the application of the wash and hatching of the eggs.

B. Control of Plum Sawfly *(Hoplocampa flava).*

For the main trial three rows each of fifty medium sized trees of the variety Czar in plantations at Pinvin, Pershore, were employed. Each row was treated as a block of five plots of ten trees and within each block the position of each of the following treatments was randomized :—

(1) Derris extract (0.16 lb.), sulphonated lorol (0.5 lb.).

(2) Derris extract (0.16 lb.) petroleum oil emulsion (1 gal.), all quantities per 100 gal. One plot in each block was left unsprayed, the remaining plots being used for other trials.

The Derris extract, particulars of which are given on p. 110, was dissolved in carbitol to form a 20 per cent. solution which, freshly prepared, was added to the concentrated spreader solution or emulsion. The latter was again the stock emulsion of 67 per cent. by volume petroleum oil (Grade G) emulsified with 20 per cent. sulphite lye (60°Tw).

To half of each plot (*i.e.* 5 trees) the spray treatments were applied a second time, one week after the first application.

The relevant data concerning the Plum Sawfly infestation are as follows :—

April 27th, 1936.	Full blossom. Only a few sawflies seen on blossom.
May 4th.	Petal fall commencing. Sawflies laying eggs during evening.
May 10th.	Petals fallen. " Cots " (receptacle) commencing to dry out.
May 18th.	" Cots " split approximately two-thirds of their length, the split commencing at base and extending longitudinally towards the open end bearing the sepals. An occasional fruitlet found bored by 1st instar larvae. First application of washes.
May 25th.	Second application of washes. A number of fruitlets just bored by 1st instar larvae.
June 11th.	Infestation in full progress. Larvae about one-third grown. All infested fruit, except first attacked, adhering to the trusses.

On June 19th the degree of infestation was determined. Four independent observers on each of the three replicates of each treatment made a randomized count of attacked and unattacked plums. Each count consisted of not less than 500 plums. Thus a total of 6,000 plums were counted for each treatment except in the case of the treatment of extract plus sulphonated lorol where 4,000 fruitlets were counted, the counts in block A being omitted because some of the trees were left unsprayed on account of a shortage of material.

The results of the trial in so far as they concern the comparative efficiency of petroleum oil as a spreader are as follows :—

TABLE VII.

Control of Plum Sawfly.

Material.	*Number of applications of wash.*	*Mean % of infested plums per block.*			*Total mean % of infested plums per treatment.*
		A.	*B.*	*C.*	
Extract plus white oil emulsion.	1	—	4.02	4.50	4.23
	2	—	1.05	1.05	1.05
Extract plus sulphonated lorol.	1	25.30	11.97	9.07	15.45
	2	2.80	2.10	2.02	2.64
Control (unsprayed)		29.11	41.33	50.81	43.86

It was evident from this trial that the efficiency of a white oil emulsion as a spreader and probably as solvent for an extract containing rotenone was appreciably greater than that of sulphonated lorol, particularly when only one application of the wash was made.

This conclusion was supported by the results obtained at the same centre in which the grower used, in a large block of mature Czars, a single application of a wash consisting of either barbasco root or Derris root, a refined petroleum oil emulsion being employed in both cases.

Wash No. 1.

1 gallon white oil emulsion (67% oil, sulphite lye).
1 lb. Barbasco Root (see p. 110).
100 gallons water.

Wash No. 2.

1 gallon white oil emulsion (67% oil, sulphite lye).
2½ lb. Derris (see p. 110).
100 gallons water.

The data relevant to this trial are as follows :—

May 18th. The condition of the " cots " as in the other trial.
May 20th. Washes applied.

Both washes provided a very high control and the difference in infestation between sprayed and unsprayed trees was clearly evident by observation.

SUMMARY.

(1). Extensive trials, carried out in various parts of the country, of a wash containing lime sulphur and a refined (Grade G) petroleum oil emulsified with sulphite lye, have shown the combination to be, in general, safe to apple varieties tolerant of sulphur. In one trial in which the oil was included in all scab sprays, serious defoliation was reported but the successful experiments have now been sufficient to justify a general recommendation of the wash under circumstances when the combined wash can economically replace the separate insecticide and fungicide applications.

(2). Evidence is given which shows that the addition of the petroleum oil emulsion does not improve the fungicidal efficiency of lime sulphur. When the petroleum oil serves no useful purpose as an ovicide or acaricide, or as a supplement for insecticides, there is no reason for recommending its use as a supplement for lime sulphur.

(3) Rotenone-containing insecticides are shown to be suitable for use in field trials for the comparison of the relative efficiencies of spray supplements as penetrants. The synthetic spreaders Agral 2 and sulphonated lorol used with rotenone-containing insecticides for the control of apple sawfly (*Hoplocampa testudinia*) have been proved more effective at 0.05 per cent. than sulphite lye at 0.75 per cent., Gamma-sulphonates at 0.05 per cent. being intermediate in efficiency. The most effective spray supplement examined was a refined (Grade G) petroleum oil emulsified with sulphite lye, the superior efficiency of which as a penetrant, may have been associated with solubility factors.

(4). The Grade G petroleum oil proved more effective than a water-soluble spreader as a supplement for rotenone-containing sprays applied for the control of plum sawfly (*Hoplocampa flava*).

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THE USE OF SULPHITE LYE AS AN EMULSIFIER.

By H. G. H. KEARNS and H. MARTIN.

The results obtained in the investigations of combined washes, of which progress reports have appeared in the Long Ashton Research Station Annual Reports since 1932 (2, 3, 4, 5), have confirmed the opinion that high-boiling petroleum oils are of great value, not only as active constituents, but as supplements of such washes. The oil is an effective carrier of contact insecticides, functioning mainly as a penetrant and solvent, and, moreover, it acts in many cases as a sticker, increasing the retention and tenacity (1) of the protective fungicides and insecticidal components of the combined wash.

The reports of the Long Ashton experiments with combined washes containing petroleum oils have lead to many enquiries from growers anxious to try out the new sprays, particularly the white oil and lime sulphur combinations. A severe handicap to the extension of the results of these experiments to commercial practice has been the lack of suitable proprietary emulsions. The majority of the petroleum oil preparations on the market are compounded with emulsions incompatible with lime sulphur and which, by reason of their alkaline reaction, cannot be fully recommended for use with lead arsenate.

The problem of the selection of emulsifiers suitable for the preparation of petroleum oil emulsions for use in combined post-dormant washes was one of the first to receive attention and the preliminary work was described in the 1932 Annual Report (2). Of the materials examined the most suitable was sulphite lye and, since that time, this product has always been employed in the emulsions used in the Long Ashton field trials. Since the original experiments, five years' experience of the merits and demerits of sulphite lye as an emulsifier has accumulated.

The purpose of this article is to place the information gained before manufacturers for their consideration in deciding the commercial possibilities of the introduction of stock emulsions compounded with sulphite lye. It is not suggested that sulphite lye is necessarily the best possible emulsifier which may be used with oil preparations for use in combined washes, nor that the grower should himself attempt the preparation of sulphite lye emulsions. The marketing of proprietary sulphite lye emulsions would, however, permit combined washes to be used to a far greater extent than is possible by using the present type of the better-known proprietary petroleum oil preparations. Although the main investigations on the use of sulphite lye as an emulsifier have concerned petroleum oils, its use as an emulsifier of tar oils, tar-petroleum oils and certain other oil-like materials, such as the organic thiocyanates, has been given extensive trial.

The Properties of Sulphite Lye.

Sulphite lye, also known as sulphite cellulose lye, lignin pitch, goulac, etc., is a name applied to a waste product from wood pulp manufacture by the sulphite process. The wood pulp is, in this process, digested with sulphur dioxide in the presence of soda or lime solutions. The sulphite lye removed from the digester is concentrated to a thick syrup or to a solid, in which forms it appears upon the market. Because of the difficulty of dissolving the solid or syrup of gravity above 60°Tw (sp.gr.1.3), a syrup of 60°Tw is used at Long Ashton.

The constituents functioning as emulsifiers are probably lignosulphonates but no suitable method of determining their content is known. At the present time the relative importance of the lack of ready methods of standardisation is reduced by the fact that in this country, so far as can be ascertained, only two firms employ the sulphite process. These firms have amalgamated and the lye is concentrated at one plant where the mixing of the various batches of lye from the digester leads to a product of greater uniformity of composition. Experience at Long Ashton of the large scale use of sulphite lye as an emulsifier is confined to this particular product. In the laboratory, sulphite lye of soda and lime bases from the continent have proved equally effective as emulsifiers.

Preparation of the Emulsion.

Equipment.

A sulphite lye emulsion of either petroleum or tar oil cannot be conveniently prepared on a commercial scale without the use of an efficient colloid mill or homogeniser.

At Long Ashton, a small Premier Colloid Mill is used capable of preparing up to 40 gallons of emulsion (66.7 per cent. oil) per hour.

The mill consists of a 5″ rotor with a smooth bevelled edge $\frac{3}{4}''$ wide running with a small clearance from a stator. The clearance can be adjusted and is set as wide as possible consistent with the preparation of a satisfactory emulsion. The mill is run at 6,500 r.p.m. and it is driven by a 5 H.P. electric motor through suitable gearing.

The requisite supplies of oil and emulsifier are mixed and fed to the mill by means of a semi-rotary all-metal pump worked at a pressure just sufficient to ensure a steady flow of emulsion from the outlet port of the mill. Gravity feed is insufficient for the rapid clearance of a stiff emulsion from the plates.

The tubing is of wide diameter to facilitate the flow of stiff emulsions and filters are fitted to ensure the removal of all grit and extraneous matter from the liquids before they enter the mill. In cold weather the presence of anthracene beads in some samples of tar oil may be troublesome and under these circumstances it will facilitate operations to heat the oil and mill. The temperature need not be raised above 17°C.

The mill is provided with a hot water or steam jacket which permits of more rapid working with oils of high viscosity, particularly in cold weather, but at Long Ashton it has not been found essential to heat the mill for the preparation of any tar or petroleum oil emulsions.

The mill is so arranged and fitted with pipe circuits that it is possible to mill large quantities of emulsions with the minimum of handling, thus providing on a small scale the conditions likely to be met in factory manufacture. The mill can be used for the preparation of small quantities of materials required for experimental purposes.

Method of Preparation.

The emulsion is prepared by the milling of the oil and sulphite lye, and the following procedure has been found to give the most consistent and satisfactory results.

The concentrated lye (60°Tw) is a thick syrup and on standing separation of its constituents occurs, more particularly crystals of sodium sulphate. It is essential that the lye is thoroughly agitated before use. The lye is best drained from its container into an open tank or vessel that permits of agitation, gentle heat greatly facilitating handling. The syrup, after mixing, is diluted with the water. Experiments over a number of years indicate that 1 part by volume of lye should be used with 10 parts by volume of oil and the volume of water adjusted to provide the concentration of oil required in the emulsion. The amount can in some instances be considerably reduced, but the recommended concentration ensures in most cases satisfactory results.

If an emulsion containing 67 per cent. oil is required, the lye syrup is diluted to a 20 per cent. solution, *i.e.* 1 part lye to 4 parts water by volume. The oil and diluted lye are measured out in the proportions by volume of 67 and 33 respectively and kept separate. The initial mixing of the lye and oil requires some care to avoid the formation of a water-in-oil (W/O) emulsion. A primary emulsion is prepared by making a mixture of 1 part oil and 3 parts lye (20 per cent.) and passing it through the mill. Thus if a one hundred gallon batch of emulsion (67 per cent. oil) is to be made, 11 gallons of oil and 33 gallons lye are thoroughly mixed and kept agitated whilst fed to the mill. The emulsion thus prepared is then pumped into a tank fitted with an agitator and re-fed *via* a pump to the mill along with the remainder of the oil, the flow of oil and emulsion being adjusted so that the ratio is 56 oil to 44 emulsion by volume. As a rule this second milling completes the operation. Considerable latitude from the above figures is possible in the preparation of petroleum emulsions, provided the primary emulsion is in the correct phase.

On the other hand tar oils and tar oil emulsions readily invert to the W/O phase unless care is used in the manufacture. If the total volume of tar oils and lye solution are mixed before milling inversion is almost certain to occur, though if passed through a homogeniser the risk is considerably less.

Treatment of Inverted Emulsions.

Sulphite lye invert emulsions can be changed from the W/O to O/W phase by milling a portion of the invert with the addition of dilute lye. For example, in the case of an inverted emulsion (67 per cent. oil) it is necessary in most cases to add to a portion of the total volume 1 part by volume of 20 per cent. lye to 3 parts by volume of the emulsion. The mixture is then passed through the mill once, or more times, when it usually changes to the correct phase. As soon as the correct emulsion is obtained it is run repeatedly through the mill and to it the remainder of the inverted material is gradually added. Generally when half the original total volume of inverted emulsion has been changed to the O/W phase it may be mixed with the remainder and the total volume milled.

The above example is given as a guide and it is stressed that the volumes quoted may vary according to circumstances. In some cases considerable manipulation may be necessary to re-invert to O/W emulsion, but it should be noted that it is always possible. Every endeavour should be made to ensure that the volume of lye solution is greater than that of the oil until a stable primary emulsion has been prepared.

The Oil Content of the Emulsion.

It is inadvisable to suggest any fixed and invariable oil content most suitable for practical use. The oil content should be one which yields a stock emulsion easy to measure and pour out under field conditions and which disperses quickly in water, preferably without any pre-mixing. These properties are most easily attained by keeping the oil content relatively low. On the other hand a low oil content increases the tendency of the emulsion to cream. As creaming causes the separation of a layer of the sulphite lye solution at the bottom of the container it results in a non-homogenous mixture and the "fool-proof" nature of the product is reduced, though it should be noted that the separated lye and cream are readily stirred into a homogeneous condition. It is advisable to aim at an oil content which yields a free-flowing emulsion but which shows a relatively small tendency to cream.

The particular oil content which effects a satisfactory compromise between these two incompatible properties varies according to the character of the oil present and to the particle size distribution of the stock emulsion. With refined petroleum oils of viscosity of about 100 sec. Redwood 1 at 70°F. and the particular mill used at Long Ashton, the oil content found most satisfactory is 66.7 per cent. by volume. At this percentage of oil creaming occurs but the emulsion can be readily remixed by agitation. The emulsifier is therefore packed in drums provided with large lids allowing of effective stirring before the emulsion is used. Drums of similar type are also required for the removal of emulsions containing more than 70 per cent. oil in which there is no, or little, tendency for creaming to occur. Generally speaking, a homogeniser produces a more uniform product less liable to cream, mainly due to the smaller particle size of the emulsion.

Bulk quantities of emulsions containing 70 per cent. oil have been kept undisturbed (in an out building) for 4 years. The material was readily mixed to a satisfactory emulsion by stirring. Moreover, the emulsions have so far withstood transport without inversion or deterioration.

No difficulty has been experienced in producing, from a given oil, different batches of emulsion of similar consistency, provided the same conditions of manufacture are employed. This point is mentioned because it is realized that manufacturers would prefer always to market a particular emulsion of a standard consistency and thereby avoid the criticism of customers, though this could largely be avoided by a guaranteed declaration of oil content.

The Emulsification of Oils other than Petroleum Oils.

Sulphite lye has been employed successfully for the preparation of stock emulsions of oils other than petroleum oils. Organic thiocyanates, such as dodecyl rhodanate (alone and in solution with petroleum oils) and Lethane 410, emulsify most readily with 20 per cent. sulphite lye solution, the general tendency being for the stock emulsion of 66.7 per cent. thiocyanate to be too viscous for easy field use.

The emulsification of tar oils has already been described and it should be noted that the chances of inversion increase with an increase in tar acid content of the oil, though once the correct emulsion has been made it remains stable.

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FURTHER OBSERVATIONS ON THE INCIDENCE AND SPREAD OF REVERSION AND BIG BUD IN BLACK CURRANTS.

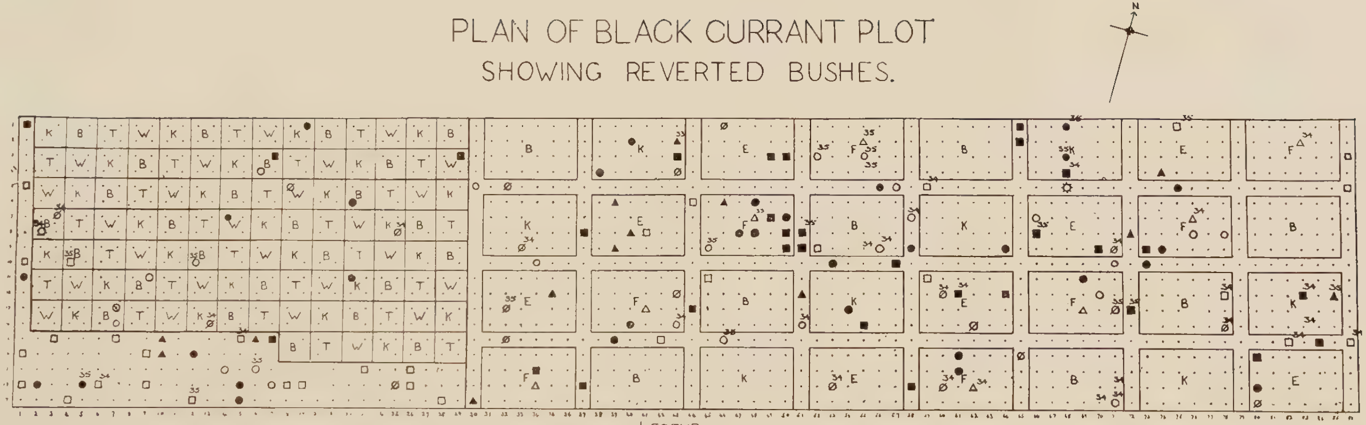
By T. SWARBRICK and W. E. BERRY.

Of the various diseases which arise in commercial black currant plantations, Reversion is undoubtedly the most insidious, since its presence may remain undetected until the disease is well advanced and infection has spread through the plantation. This will almost certainly happen unless reliable material is planted and careful roguing is carried out at the appropriate time of year. The disease, the symptoms of which have been described by Amos and Hatton, (1) is believed to be due to a plant virus and Lees (8) succeeded in transmitting it by grafting reverted shoots to healthy stocks. Information regarding its normal mode of dissemination is however scanty and unsatisfactory. In practice, it is often found in association with "Big Bud," and the possibility arises that the Black Currant Mite (*Eriophyes ribis*), which causes Big Bud, may be responsible for the spread of Reversion from diseased to healthy bushes. This possibility was investigated extensively by Lees. His results, published in the Annual Reports of the Long Ashton Research Station for the years 1919-1925, strongly suggest a causal relationship between the activities of Big Bud Mite and the occurrence of Reversion. His observation that bushes strongly attacked by Mite are invariably reverted has been confirmed by the data recorded in this paper. He produced evidence (6) which suggested that reverted bushes were more liable to attack by Big Bud Mite than normal bushes, but on the other hand his experiments on direct infection of healthy bushes with mite (8), in which five out of eight bushes successfully infected with Big Bud became reverted, show that Reversion may be a direct result of mite attack. At the same time, his field observations led him to believe that aphides could not be ruled out as possible carriers of Reversion.

The data on Reversion and Big Bud recorded in this paper were collected during the course of the black currant variety trial reported elsewhere in this volume (9). They are presented here as additional evidence for the coincidence of the two diseases and as throwing some light on the factors which may influence the spread of Reversion in a large scale plantation.

Fig. 1.

PLAN OF BLACK CURRANT PLOT
SHOWING REVERTED BUSHES.



LEGEND.

△ Original reverts.
✡ Reverted 1929. K - Boskoop Giant.
☐ " -30. B - Baldwin
○ " -31. T - Taylor
Ø " -32. W - Westwick
▲ " -33. E - Edina.
■ " -34. F - French or Seabrook Black.
● " -35. All other, bushes French.

Numbers over symbols indicate dates of appearance of Big Bud symptoms.

A preliminary report was published in 1931 (2) when the results obtained during the first four years after planting were discussed. The provisional conclusions arrived at were to the effect that new cases of Reversion could not be associated definitely with previous cases, but that the disease was probably present in an incipient stage in the bushes at the time of planting.

EXPERIMENTAL.

Materials and Methods.

The material used was the same as that used for the variety trial described elsewhere in this Report (9). The layout of the plots, manuring, pruning and spray programmes have been already described (*loc. cit.*). The Long Ashton material (see p. 66) shown on the east of the plot in Fig. 1 was relied on for most of the information required. This material was raised in the Research Station nurseries and was carefully rogued for Reversion and Big Bud during the two years prior to planting. Routine applications of a tar distillate wash in winter, lime sulphur in spring and Bordeaux mixture in late summer have been made every year except 1932, when the two former sprays were omitted. The control of biting and sucking insects has been most satisfactory. Capsid Bugs have never been found on the plot, and occasional small infestations of aphis on isolated bushes have been effectively dealt with by means of a small hand dusting machine.

It was originally intended to plant reverted bushes of all the four varieties, Baldwin, Boskoop, Edina and French, at known places in the plot in order to determine whether new cases of Reversion arose by infection from previous cases. Owing, however, to the difficulty of obtaining suitable material of the three former varieties at the time of planting, it was only possible to plant reverted bushes of French. The positions intended for the reverted bushes of the other varieties have consequently been left vacant. Since the winter of 1927-28 when the experiment was begun, data on the incidence of Reversion and Big Bud have been collected every season until 1935.

RESULTS AND GENERAL DISCUSSION.

The distribution of Reversion over the whole plot in succesive years is given in Fig. 1, the Wisley material being on the west side and the Long Ashton on the east.

a. Wisley Material.

The numbers of reverted bushes occurring in successive years in the different varieties on the Wisley plot are given in Table 1.A. The degree of infection is relatively light, amounting to only 17 cases out of 406 bushes during the whole period of 8 years. These cases seem to be spread more or less at random over the plot, but the earliest infections have arisen on the south side, which suggests that they have originated through proximity to the large block of unselected bushes of the variety French planted to fill up space in the position shown in Fig. 1 (*c.f.* previous report). The very large proportion of bushes in this block which have developed symptoms of Reversion serves to illustrate the importance of planting only rigorously selected and rogued material. Observations on the occurrence of Big Bud in the Wisley material will be mentioned later.

b. Long Ashton Material.

The records for the incidence of Reversion in the experimental blocks of this material are given in Table 1 B, and since reverted bushes in the buffer rows (variety French) may also act as sources of infection, these are also recorded. It is evident from the plan that the reverted bushes planted originally as known sources of the disease are not distributed at random over the plot but occur in two lines running approximately north-east to south-west. The centres of infection are thus at the outset considerably localised.

In seeking an explanation of the spread of Reversion over the plot three possibilities present themselves.

1. Reversion may be carried from the original centres of infection.
    - (*a*) By cultural operations such as pruning, picking, etc.
    - (*b*) By the activities of insects.
2. Apparently new cases may arise by a recrudescence of the disease in bushes which were regarded as healthy when planted.
3. Infection may be brought in by insects from outside the plot.

In order to test the possibility that infection spreads from previously reverted bushes, it is useful to compare the density of population of reverted bushes in the immediate vicinity of the original centres of infection with the mean density over the whole

TABLE 1.

Showing Total Numbers of Reverted Bushes Each Year Since Planting.

	Variety.	*Total Bushes*	1929	1930	1931	1932	1933	1934	1935
A. Wisley.	Baldwin	104	None	1	7	8	8	9	10
	Boskoop	104	None	None	None	2	2	2	4
	Davison's Eight	104	None	None	None	1	1	2	3
	Taylor	104	None	None	None	None	None	None	None
B. Long Ashton.	Baldwin	184	None	3	5	6	6	6	6
	Boskoop	184	None	None	None	2	4	8	14
	Edina	184	None	3	4	11	16	23	24
	French	192	None	None	7	10	11	16	24
	French in Buffer Rows	306	1	8	15	17	20	31	37

plot. For this purpose, two strips of the plot may be studied, formed by joining all the south-easterly corners of the blocks of French and all the north-westerly corners respectively. These two strips together enclose an area containing 28% of the total number of bushes on the plot, and on examination are found to contain 48% of the total population of reverted bushes. In other words, almost half the total number of reverted bushes occurs within an area little more than a quarter of the size of the whole plot. Or, whilst the mean density of population of reverted bushes over the whole plot is only 8.3%, in the two strips enclosing the originally reverted bushes it is 28%, more than three times this value, omitting of course the originally planted reverts from the calculation. This would seem to indicate that new cases of Reversion definitely arise more frequently in the neighbourhood of previously infected bushes, unless the particular strain of virus responsible for the disease is specifically adapted to the variety French. Further evidence for the spread of infection from previously recorded cases may be derived from a consideration of the sequence of new infections from year to year, when it appears that in only 4 cases out of 107 have new infections arisen at a greater distance than 6 bushes from a previously reverted bush, whilst only 29 are separated by more than 2 bushes from previous cases. There are thus good grounds for believing that the majority of new cases of Reversion have arisen by transmission of infection from the original centres, and we may proceed to examine the factors which may be operative in determining this spread.

The distribution of the disease may be influenced by several factors.

(*a*) The sequence of cultural operations, particularly pruning.
(*b*) The relative proximity of different varieties to the original sources of infection.
(*c*) The uniformity of insect control and the distribution of insects.

Cultural Factors.

Pruning. The order of pruning adopted would seem to rule out the possibility that Reversion was in fact spread by this means. All the bushes known to be reverted were pruned first and the prunings burnt, this being done to prevent workmen taking cuttings for propagation from reverted bushes. The healthy bushes were then pruned, a whole block of one variety being done at a time. Whilst the possibility of spreading infection by pruning is admitted, it seems that Reversion may spread to a considerable extent even when precautions are taken of the kind mentioned. The possibility remains, however, that pruning may have spread infection from slightly affected bushes which only showed obvious symptoms at a later date.

Spraying. The application of spray materials was as uniform as is possible and there is no reason to suppose that any one position on the plot more than another harboured insects which might have increased the incidence of Reversion in that region.

Effect of Variety and Distance from Infection Centres.

The arrangement of the plots adopted for the variety trial does not lend itself easily to a comparison of the susceptibility of the different varieties to Reversion. Certain possibilities, however, call for comment. The data in Table 1B might be taken as suggesting a greater susceptibility in French and Edina than in Boskoop and Baldwin, but an alternative interpretation, discussed in the next section, is possible. Lees (1922) reported that the variety Edina was very susceptible to both Big Bud and Reversion compared with Boskoop, Baldwin and Seabrook. His Edina material, however, obtained from a commercial grower, contained the amazing proportion of 73% of big-budded plants, and showed 20% Reversion the first summer after planting. Whilst he states that all the big buds were carefully removed on planting, it is obvious that conclusions based on subsequent comparisons of this material with the other varieties, which were almost entirely free from disease at the outset, should be accepted with caution. The percentage of big-budded bushes in the four varieties during the present experiment are given in the following table, from which it is clear that Edina is not more heavily infested than the other varieties.

TABLE 2.

% BIG BUD BUSHES, 1929–1935.

Boskoop.	*Baldwin.*	*Edina.*	*French.*	*French in Buffer Rows.*
4.3	3.8	3.8	6.2	2.6

The difference in numbers of reverted bushes in the different varieties given in Table 1 B may be determined both by differences of susceptibility and by differences of position in the plot relative to the initial sources of infection. The distribution of blocks of the different varieties relative to these centres is not uniform, due to the method of distribution adopted for the variety trial and the confinement of the original reverts to the variety French. Each block of French is bounded on the north and west by blocks of Edina and on the south and east by blocks of Baldwin. The blocks of Boskoop lie roughly to the north-west and south-east but considerably further away. Otherwise stated, blocks of Baldwin and Edina lie in parallel lines on each side of the lines of French blocks, whilst the Boskoop blocks lie outside these. This arrangement will be made clear by reference to the planting plan. It follows that a circle of radius 30 ft. (= 6 bushes) round a centre of infection, encloses about 29 bushes of French, 29 Baldwin, 25 Edina and only 4 of Boskoop, whilst a circle with half this radius would enclose French exclusively. If we assume all four varieties to be equally susceptible, and infection spreads from the centres, the Boskoop bushes have a very small chance of infection compared with the other varieties and we should have a preponderence of cases in the variety French, fewer in Baldwin and Edina, and relatively very few in Boskoop. That this is not in fact the case is clear from Table 1 B. The recorded cases are fewest in Baldwin, which has less than half the number of reverts shown by Boskoop over the full period of eight years, whilst the infections in French bushes are no more frequent than in Edina. On the other hand, in point of time, Boskoop is last to show any cases of infection, all the bushes of this variety being recorded as healthy until 1932. It is clear therefore that some factor or factors operate to displace the symmetry of the areas of infection round the initial centres in such a way as to increase the number of infections in Edina and to decrease the number in Baldwin relative to the number in French. If we accept the general opinion of growers that Edina is particularly subject to Reversion, we have one possible explanation of this one-sided spread of the disease. Another possibility is concerned with the activities of the Big Bud Mite.

The Distribution of Big Bud Disease.

The relation between Reversion and Big Bud is brought out by a study of Fig. 1. The bushes on which big buds have developed during the course of the experiment are recorded by a number indicating the year in which the symptoms were first noted. In the Long Ashton material, including buffer rows, 43 cases of Big Bud were recorded, 38 of which occurred on reverted bushes. In the

Wisley material and the subsidiary block of French together, 10 cases of Big Bud occurred and all were on reverted bushes. There are, in addition, on both plots together, 47 bushes which have Reversion but show no obvious symptoms of Big Bud. It is clear therefore that, as observed by Lees, bushes affected by Big Bud are almost invariably reverted. When, however, the data are examined, it appears that in every case where Reversion and Big Bud occur on the same bush, Reversion has been recorded two or three seasons before Big Bud, except in 7 cases where they were recorded in the same year. In no instance was Big Bud recorded before Reversion, and no case was recorded prior to 1933. This would seem to lead to the conclusion that Reversion precedes Big Bud, and that mites attack reverted in preference to healthy bushes, but if this were so it would be difficult to explain the greater incidence of Reversion in the vicinity of previous sources of infection. There is, moreover, a suggestion that Reversion has tended to spread in a north westerly direction from the infection centres, which might be attributed to the frequent occurrence of easterly and south-easterly winds during late February, March and early April, when Big Bud Mites are migrating. This would explain the relatively small number of reverts amongst Baldwin Bushes and the relatively large number in Edina, since the former lie immediately to the windward and the latter to leeward of the original reverts. It is impossible however to decide definitely whether the observed distribution is related to wind direction or to the varietal differences already discussed. There is obviously a close connection between the occurrence of Reversion and Big Bud, and it seems legitimate to conclude from the evidence of Lees, and the additional data presented here, that the Big Bud Mite is responsible to a large extent for the spread of Reversion. This conclusion, however, involves the assumption that bushes can be infected with mites for several seasons before the usual Big Bud symptoms appear, an assumption which receives support from the fact that mites may be present in considerable numbers without building up the large population necessary to produce the typical big buds which have been regarded in these experiments as the criterion of mite infestation. It should be recalled in this connection that heavy infestations of mite are known to occur on red currents (3) without the production of big buds such as occur on black currants, and it seems probable that a similar state of affairs may exist in the case of the latter when the mites are not present in very large numbers.

SUMMARY AND CONCLUSIONS.

1. Reverted bushes were planted at fixed positions in a large black currant plantation and the time and place of the occurrence of new cases recorded during eight successive years.

2. New cases of Reversion were more frequent in the vicinity of the originally planted reverts.

3. There is some indication that the variety Edina is more susceptible, and the variety Baldwin less suceptible to Reversion than French.

4. Big Bud occurred almost exclusively on reverted bushes, but since big buds have never been observed prior to the symptoms of Reversion it cannot be concluded that Big Bud Mite is definitely responsible for the spread of the disease unless it can be shown that mites may be present on a bush for several seasons in sufficient numbers to transmit Reversion and yet be insufficient to produce Big Buds.

5. The evidence points to the possibility that many new infections arise through the activities of the Big Bud Mite, but other means of spreading the disease are not precluded and it is possible that some of the bushes had the disease in a mild form when planted, and developed symptoms later.

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EXPERIMENTS ON THE CONTROL OF LICHEN ON APPLE TREES BY MEANS OF TAR OIL WASHES.

By J. E. FORSHAW,* H. G. H. KEARNS and H. MARTIN.

Introduction.

The demand for cider apples has encouraged more attention to methods of increasing the crops from established trees. A familiar feature of West Country cider orchards is lichen and moss growth, the removal of which from the trees is the first essential step as a means of promoting healthy tree growth and development of fruit buds. The importance of lichen destruction has been long recognised and various materials have been used as control measures. Waite (3) in 1893 reported the successful use of Bordeaux mixture applied in March, though this method does not appear to have been adopted, probably because the wash did not possess any ovicidal properties to insect eggs. Later, Theobald (2) and others recommended the use of caustic soda and lime-salt washes; the latter were extensively used until the introduction of tar oil washes which entirely replaced them on account of their superior properties as ovicides to aphides and Apple Sucker. It is well established that regular applications of tar oil washes control lichen completely in orchards consisting of dessert and culinary varieties of apples.

In 1928, Long Ashton neutral, high-boiling tar oil washes were introduced and observations suggested that these washes were less effective against lichen than washes compounded from oils of lower boiling range. In order to test these observations critically a field experiment was carried out in Somerset in 1935 with tar oil washes of various specifications in which observations were also made on the control of insect pests.

The results showed that tar oils of high boiling range were more effective than those of low boiling range against the lichen, but that a severe lichen infestation could not be completely controlled in one season. The control of Aphid, Sucker and Winter Moth by high-boiling tar oils was fairly satisfactory.

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* Somerset Farm Institute, Cannington.

Notes on Lichen and Moss Infestation of Fruit Trees.

Lichen infestation, judged from the health point of view of apple trees, is of greater economic consequence than moss infestation, but there appears to be confusion as to the relative economic importance of the various species of lichens infesting living apple trees. There are a number of lichen species associated with the bark of the apple, but in Somerset the most common is *Evernia prunastri* (Fig. 1). This species is associated with living wood. On the other hand, mosses do not as a rule invade healthy, established trees to any extent. They live usually on decomposing bark or on the organic material which has become lodged in the cracks of rough or peeling bark. Their presence frequently indicates that the tree or the individual portion of the tree is dead or dying.

The comparatively rapid growth of young trees results in an expansion of the bark and therefore lichens do not become well established in the early years of the tree's life. When the growth of the tree slows down and rough bark develops, then the larger species of lichen, under favourable climatic conditions, invade the bark and rapidly cover it with a dense layer of growth. This condition still further retards the growth of the tree. *Evernia prunastri* is one of the largest filamentous species and it is attached to the bark by means of hyphae which penetrate into the periderm *via* the lenticels. The rough bark of older trees collects and retains the moisture which is essential for the prolific growth of this lichen. and thus it is not infrequent to find the side of the tree exposed to wind and rain most densely infested. Long, mild autumns and early, mild, wet springs are particularly favourable for the rapid development of the lichens. It is able by means of its xerophytic structure to withstand extremely hot weather and even prolonged exposure to direct sunlight. Lichens become limp during wet weather and they are easily torn. During winds portions are detached and become lodged on fresh bark. In addition, the species are distributed by means of detachable vegetative structures known as soridia.

The extent of the damage caused by the presence of dense clusters of lichen is difficult to assess, but there is no doubt that it produces serious consequences. The smaller branches and twigs become thickly encrusted with lichen and with broken-down and splitting bark. Many of the flower buds are smothered and either die or are so weakened that they are unable to produce healthy flowers. Wood in the centre of the tree dies out if the infestation is allowed to continue and the tree remains unpruned for a few seasons. Eventually fruit is only borne on the periphery of the tree.

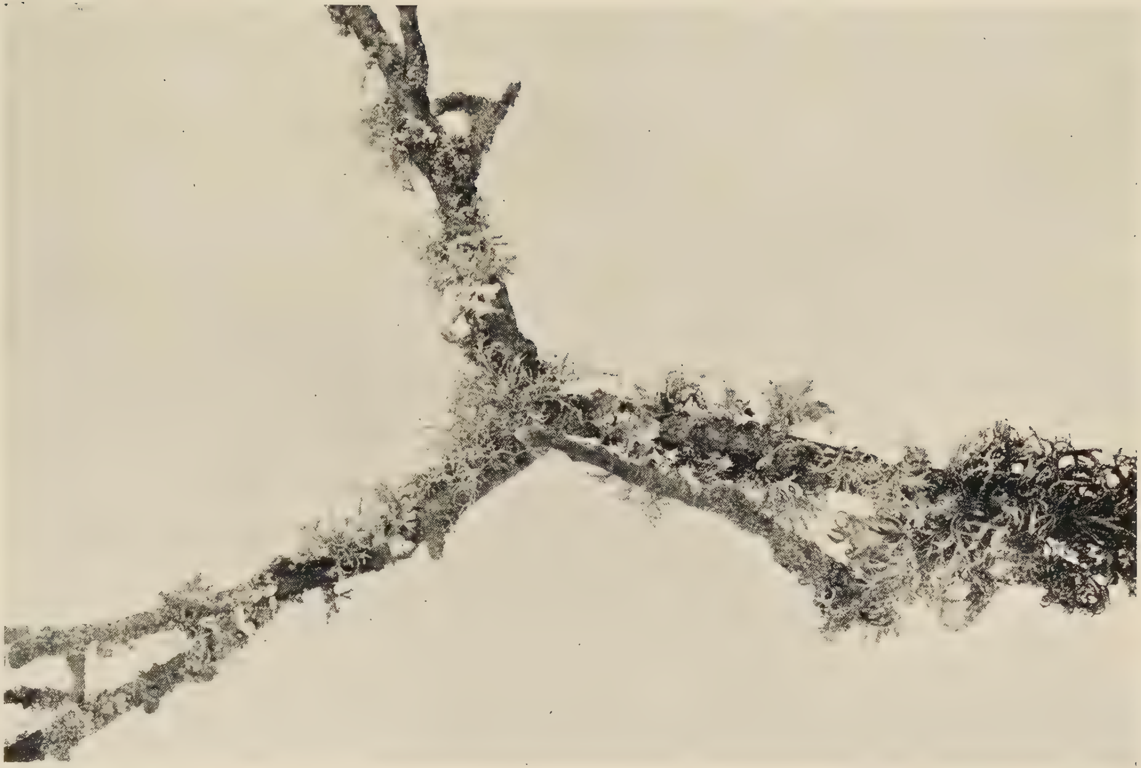

FIG. I. Typical specimen of the lichen *Evernia prunastri* on apple wood.

Aphid eggs are not as a rule laid in any numbers on lichen-infested bark, in fact the oviparous female aphides show a marked preference for healthy wood. This observation does not apply to Sucker (*Psyllia mali*) which is often an un-noticed pest of cider orchards. Sucker attacks the developing blossom trusses and still further weakens the flower buds already weakened by lichen. Lichen does not, as frequently imagined, harbour insect pests.

Field Experiments.

Materials.

Six washes, described in the text as A, B, C, D, E and F respectively, were tested as means of controlling lichens. The composition of each wash is given in Table I. A, B and C consisted of tar oils; D, E, F were mixtures of tar and petroleum oils. Washes A and B complied with the specifications (Grades A and B respectively) defined by Martin (1). A, C and F were of special interest. A was a Long Ashton neutral high-boiling tar oil compounded with oleic acid, and C a low-boiling tar oil. F was a combination of low-boiling tar oil, with a high tar acid content, and petroleum oil.

TABLE I.

Analysis of the Concentrates of the Washes.

	A Grade A tar oil.	B Grade B tar oil.	C	D	E	F
Type of Emulsification—	2-solution	2-solution	Stock Emulsion*	Miscible Oil	Miscible Oil	Miscible Oil
% by weight :						
Neutral oils	78.6	75.7	65.0	64.6	66.7	63.0
Tar acids	3.6	7.4	4.7	8.4	8.8	16.1
Tar bases	4.5	4.1	1.8	3.4	2.6	1.9
Total oils ..	86.7	87.2	71.5	76.4	78.1	81.0
Resin and fatty acids ..	10.2	10.3	3.0	7.5	12.7	11.3
Neutral oil :						
Sp.Gr. (60°F)	1.063	1.049	1.034	1.002	1.010	0.883
Boiling Range :						
90% above	274°C	253	228	249	263	227
50% above	337	306	265	310	353	270
20% above	390	352	326	363	389	325
Dimethyl sulphate :						
% by vol. insoluble in ..	0.0	6	0.0	31.5	40	52
Unsulphonated residue :						
% by vol.	—	—	—	—	—	43

* 8.0% by wt. solid anthracenoid hydrocarbons.

The washes were applied at the concentrations shown in Table II.

TABLE II.

Analysis of Washes as Applied.

	A	B	C	D	E	F
% Concentration of wash	8.5	8.5	12.5	10.0	10.0	10.0
% Total oils	7.4	7.4	8.9	7.6	7.8	8.1
% Neutral oils	6.7	6.5	8.1	6.5	6.7	6.3
% Tar acids	0.3	0.6	0.6	0.8	0.9	1.6
% Neutral oil soluble in dimethyl sulphate (tar oils)	6.7	6.1	8.1	4.4	4.0	3.0
% Neutral oil insoluble in dimethyl sulphate	0.0	0.4	0.0	2.1	2.7	3.3

Lay-out of the Trial.

An orchard severely infested with lichen and consisting mainly of established trees of cider varieties with a few scattered Bramleys was selected as suitable for the purposes of the trial.

The orchard was of irregular shape and it was divided into blocks so that each included a few trees adjacent to a stream, where the lichen infestation was especially severe. Unsprayed trees were left as controls.

The six washes were applied on the 28th February and 1st March, 1935, by means of a small power outfit which was inadequate for the thorough treatment of the taller trees. Two of the smaller trees were, therefore, carefully drenched with Wash A to ascertain whether a soaking application provided better control.

Results.

In mid-June, estimates of degree of control of lichen and insect pests were taken. Winter Moth and Tortrix larvae had just left the foliage and aphides (*Anuraphis roseus*) were nearly all winged and about to migrate.

It was difficult to assess the results accurately on account of the lack of uniformity of the growth of, and masses of dead wood in, individual trees.

The assessments were made in the following grades :—

Lichen. Lichen apparently dead = Grade 1
Intermediate Grade between 1 and 3 = .. 2
Lichen partly green = .. 3
No observable effect = ,, 4

Pests. Satisfactory control = Grade 1
Moderate control = ,, 2
Poor control = ,, 3
No control = ,, 4

An inspection at the end of September, 1935, indicated definitely that high boiling tar oils had given the best results. By January, 1936, the lichens had had time to recover and further estimates were made. In July, 1936, it was evident that winter washing had had lasting beneficial results, although it was clear that even on the drenched trees the control of lichen was not complete. The trees, especially the Bramleys, had healthier looking foliage than the unsprayed control trees. In mid-November, 1936, final observations showed that in most cases when a good kill of lichen had been made, re-establishment was slow. The chief exception to this was Wash A, where lichen appeared to be growing again quickly.

The results of the observations are expressed numerically, according to the grades described above, in Table III.

TABLE III.

Wash.	Lichen.			Winter Moth.	Aphid.
	13.6.35	29.1.36	16.11.36	13.6.35	13.6.35
A	2	1	3	1	1
Control	4	4	4	4	1
B	3	1½	1	1	1
C	3	3	3	2	1
D	3	1	2	1	1
E	1	2	2	2	1
F	2	1	1	3	1

Conclusion.

Under the conditions of the trial, high-boiling tar oils afforded the greatest measure of lichen control and freedom from Winter Moth. The degree of lichen control obtained, although considerable, is in itself insufficient to justify the recommendation of only a single application for severe infestations. It is evident from this trial and from other data, that the liberal application of a tar oil wash in at least two successive winters is essential for complete lichen control.

Acknowledgments.

Sincere thanks are due to Mr. W. T. Allen, who very kindly permitted the trials to be carried out in one of his orchards and also provided the necessary facilities.

Thanks are also due to Mr. W. Hecks, who made the spray applications.

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PROGRESS REPORT ON VEGETABLE DISEASES.—VIII.

By L. OGILVIE and C. J. HICKMAN.

The following report is a summary of the work on Vegetable Diseases in the Bristol Province carried out during the season 1935-36 and is a continuation of those published previously.

ASPARAGUS DISEASES.

Asparagus Rust.

During 1936 surveys of the asparagus areas in Worcestershire were again made, but no cases of rust (caused by *Puccinia Asparagi*) were observed.

Violet Root Rot.

Five new centres affected with *Rhizoctonia Crocorum* were discovered in 1936. The total number of affected areas recorded in Worcestershire is now sixteen. In some of these the number of affected plants was very small and the grower was able to dig them up with some confidence of eradicating the outbreak entirely. The importance of early eradication of diseased plants and of maintaining infected ground free from asparagus for some years has been again emphasised.

Spotting of the "Bower."

Two separate plantings of asparagus strains, said to have been derived from the "Washington" varieties, showed extensive spotting of the stems and bower accompanied by some premature fall of the "needles." *Macrosporium* sp. and other fungi were associated with the trouble.

DISEASES OF DWARF BEANS.

Anthracnose.

This disease, caused by the fungus *Colletotrichum lindemuthianum*, is not usually very common in England. It has been referred to briefly by Mrs. N. L. Alcock (1). It was apparently favoured by the cool and moist summer of 1936 and was very prevalent on the variety plot of dwarf beans at Long Ashton. The disease occurred evenly over the plot. Table I showing the degree of infection on the different varieties.

TABLE I.

Dwarf Bean Varieties in relation to Infection with Anthracnose.

Infection Severe.	*Infection Moderately Severe.*	*Infection Slight.*	*Free from Disease.*
Black Prince.	Black Wonder.	Lightning.	Princess.
Masterpiece.	Victory (Afrikander).	Unrivalled.	Hundred for One.
Bountiful.	Sunrise.	Best of All.	
Plentiful.	Dwarf Abundant.		
Evergreen.	Magpie.		
The Prince.	Leicester Wonder.		
Full Measure.	Premier.		
Early Prolific.			
Ne Plus Ultra.			
Canadian Wonder Improved.			
Incomparable.			
Satisfaction.			
Goliath.			
New Stringless Greenpod.			
Stringless Green Refugee.			
First of All.			

It is intended to carry out inoculation experiments with pure cultures of the fungus on a large number of English varieties of beans in 1937.

The work of Barrus (2) and others in America has shown that three physiologic forms of the fungus exist there, differing in their capacity of infecting certain varieties of beans. Schreiber (14) has recently distinguished 34 forms of the fungus, differentiated by their capacity of infecting 30 varieties of dwarf beans, most of which are continental sorts. These 34 forms, however, can be grouped together into 3 classes corresponding to Barrus's groups.

It is of interest that the variety Princess or Sugar Pearl, which Schreiber found to be immune to 19 of his strains, was unaffected in our trial. Most of the varieties commonly grown in England have not been tested for their susceptibility or otherwise to anthracnose. The recent classification of these beans by Hoare (10) will enable it to be ascertained whether resistance is in any way correlated with these groupings.

It may be noted that the most effective control measure in the United States has been the use of anthracnose-free seed, which can be secured by growing plants for seed in the arid regions of the Western States.

Halo Blight.

Halo Blight, caused by *Bacterium Medicaginis* var. *phaseolicola*, was relatively infrequent in 1936, and did not appear sufficiently in variety trials for any conclusions to be drawn.

Field trials in other countries have substantiated our findings in 1932 (12) regarding the resistance of certain varieties. Thus Wager (16, 17) found that Black Wonder, Black Prince, Abundant, de Lignereux, Magpie, Superlative and The Prince were comparatively resistant in South Africa and had suitable commercial qualities, there being little to choose between them and the highly susceptible Canadian Wonder as regards yield and quality of beans. Black Wonder, Black Prince and de Lignereux consistently produced good, uniform crops and were considered to be excellent commercial varieties. Black Wonder was grown on a large commercial scale with great success.

Pugsley (13) who conducted trials in Victoria, Australia, found that under local conditions Black Prince, Black Wonder, Superlative and Ne Plus Ultra were moderately resistant, whereas Canadian Wonder was highly susceptible.

Mosaic Disease.

In the Long Ashton plantings mosaic disease was rather prevalent, the symptoms being most marked on the varieties Emperor William and Keeney's Stringless Refugee, the canning variety now commonly grown in this country. On the former, the downward cupping and mottling of the leaves recently described by Harrison (7, 8, 9) as typical of bean mosaic in America were very evident. Dr. J. G. Horsfall, who has recently worked at Long Ashton, has pointed out to us on Keeney's Refugee and on other varieties, the hydrotic or water-soaked spots which are somewhat suggestive of Halo Blight infection but which are in reality a symptom of mosaic infection. These spots become brown after the beans have been canned. Mosaic plants also tend to produce curved and crooked pods, hence any prevalence of the disease on canning beans may cause considerable loss. It is not known at present, however, to what extent the disease occurs in commercial plantings in this country.

Foot Rot.

Foot rot, caused by *Fusarium Solani* var. *Martii*, was again prevalent in Worcestershire. Seeds of apparently resistant varieties are being selected. A further detailed study of this and other *Fusaria* affecting dwarf beans in this area is being carried out by D. L. G. Davies, a post-graduate student.

DISEASES OF RUNNER BEANS.

Sclerotinia Disease.

A *Sclerotinia* disease was prevalent on runner beans at Offenham, Worcestershire, in July, affecting the bases of subsidiary branches. The affected branches wilted and collapsed. The disease occurred sporadically throughout the plantings. The fungus has been secured in culture. It seems important to ascertain whether it is *S. Sclerotiorum* or *S. Trifoliorum*.

DISEASES OF BRASSICAE.

Dry Rot.

An experimental planting of swedes at the Research Station was destroyed by Dry Rot, caused by *Phoma Lingam*. This disease, which is not commonly reported in the Province, has recently been worked on by Buddin (5), who has found that it is not commonly carried over on the seed. E. H. Wilkinson, a post-graduate student, is at present investigating the question of biologic forms of this fungus.

Whip-Tail.

In 1933 a peculiar disease of cauliflowers and savoys was under observation at Ross-on-Wye, about 75% of the crop being affected. The leaves were strikingly deformed and strap-like, the laminae being much reduced. The affected plants were usually scattered about the fields, but in other cases they were found in groups.

The disease was again prevalent to a serious extent in July, 1936, in plantings of early cauliflower at Mickleton, Glos. In this case there was, in addition, a development of leaves amongst the "curd." The affected plants occurred in fairly well-defined areas in which the grower said the disease had been present in previous years.

The symptoms of the trouble greatly resemble those of " Whip-tail," which has been reported upon by Clayton (6) in America. It has been attributed there to lime deficiency. Samples of soil showed, in the Ross case, 0.098% exchangeable CaO, with a pH of 4.99, and in the Mickleton case 0.762% and 0.859% exchangeable CaO from two samples, both of which contained free calcium carbonate.

Mosaic.

A mosaic disease of cabbages and other Brassicae was referred to in our 1934 Report. Specimens were submitted at that time to Dr. K. M. Smith, who stated that he had already had the disease under observation. The virus affects wallflowers and other cultivated crucifers, bringing about " breaking " of the flowers. As indicated by Smith (15) the disease can cause serious stunting of cauliflowers and broccoli.

DISEASES OF CARROTS.

Soft Rot.

Soft rot of carrots, caused by bacteria of the *Bacillus carotovorus* group, was common in October on heavily manured ground. A similar soft rot occurred on turnips and leeks. A comparison of cultures from these with bacteria isolated from soft rots of celery (see 1934 Report) Brassicae, hyacinths and cyclamens is in progress.

DISEASES OF LETTUCES.

During the year, a paper (3) was published by P. W. Brian dealing with the work he carried out on the classification of cabbage lettuces while in this department. Brian has classified these lettuces into groups according to their seed-colour, leaf texture, leaf pigment, depth of leaf colour and season of use. The classification is of great value in affording to the grower clear guidance on the selection of varieties for growing at different times of the year.

It is hoped eventually to issue a table indicating the susceptibility of cabbage lettuce varieties to various diseases. Some indication of the response of the varieties in the different groups to mosaic disease has already been given in last year's report.

A list of some 270 cabbage lettuce varieties grown in England is in course of preparation. This list indicates the source of the seeds, the seed colour, the group to which the variety is considered to belong, its market value and its response to various diseases.

Some 150 lettuce varieties on trial during the summer were allowed to flower, and a critical examination indicated that there are distinct flower differences in certain of Brian's groups.

Variety Trials.

A number of variety trials were laid down with the object of classifying the varieties, of assessing their market value, their winter hardiness, their value as summer lettuces and their response to mosaic disease, *Botrytis*, *Marssonina*, etc. The details of these trials are to be incorporated in a final summary of field trials and will not be reported here, but some indications of the results of the trials are given below :—

1. *Winter Lettuce Trial, Long Ashton*, 1935-36. This trial was on very light soil which imposed a very severe test of winter hardiness, so that only 35 of the 137 varieties had more than 50% survival. 53 out of the 137 varieties were badly attacked by *Marssonina.*

2. *Winter Lettuce Trial, Perdiswell*, 1935-36. This trial was carried out in conjunction with the Worcester County Council Agricultural Department. 41 varieties were on trial, and of these only 14 sorts had more than 50% survival. Little *Marssonina* was present. The number of mosaic plants was small in every case, as in all the trials. Each variety, however, had a few affected plants and useful notes were made on the response of the varieties to infection.

3. *Winter Lettuce Trial, Frenchay.* This trial was carried through by Messrs. J. & J. Brown, who included a number of varieties of their own choice in the trial. There were 23 varieties in all, of which only 12 were of market value. There was an average of only about 2% mosaic infection. 16 varieties had more than 50% survival.

4. *Forcing Lettuce Trial, Long Ashton, Winter* 1935-36. 10 varieties were under trial, and of these 3 belonged to the Gotte Class, 6 to the May Queen Class and 1 was doubtful. The first group were much superior to the second, which developed excessive *Botrytis* rot at the collar and on the leaves.

5. *Summer Lettuce Trial, Long Ashton*, 1936. This trial comprised 89 varieties. The great majority of these grew successfully and notes were made on classification, size, texture of leaf,

type of flower and market value. Little disease occurred in any of the varieties. Botrytis disease occurred sporadically when the plants were nearly mature. "Drop" caused by *Sclerotinia* spp. also occurred here and there: it is being ascertained whether any species other than *S. Sclerotiorum* are implicated. Mosaic disease was very sparingly present. A number of plants showed a condition suggestive of "big vein" (11), an obscure mosaic disease of lettuce which occurs in the U.S.A. and which has been observed previously in other local plantings.

Observations were also made on lettuces in cultivation by growers throughout the Province.

Mosaic Disease.

Mosaic disease was very sparingly present in the spring of 1936, no doubt owing to the previous severe winter, which checked the multiplication of aphides. In no case were more than 10% of the plants affected. It may be noted, however, that the aphis *Macrosiphum gei* occurred sparsely in seedbeds at Evesham as early as October 9th, 1935, and that distinctly mottled plants were observed by that date. Further work was done on the transmission of the disease and attempts were made to transmit it to a perennial lettuce *Lactuca perennis*.

Botrytis Disease.

Remarks have already been made on the occurrence of this disease in the various trials. Lack of winter hardiness is usually accompanied by *Botrytis* infection while, in both forcing and summer varieties, the shape of the lettuce and its texture have much to do with susceptibility.

All the summer varieties in the Long Ashton trials were allowed to flower. The leaves were severely attacked by *Botrytis* and most of the seeds which were gathered were heavily infected with mycelium in the cotyledons. This mycelium was still viable after two months, and when the seeds were sown patches of *Botrytis* were produced in the soil which served as infection centres for the healthy seedlings. Several commercial samples of lettuce were examined and one of these was found to contain infected seeds.

Brown (4) has recently reported considerable control of Botrytis in frames and glasshouses from the use of a proprietary organic mercury dust. Trials carried out by us with this and three other dusts on groups of six different varieties growing on heavily infected soil in the greenhouse gave no significant control.

Ring Spot.

Marssonina panattoniana has been got into culture and inoculation experiments with this fungus are now in progress.

Possible Deficiency Diseases.

Field and greenhouse trials are in progress to determine the possible connection of deficiences of potash, boron and manganese with tip burn and leaf scorch in lettuces.

DISEASES OF LEEKS.

White Tip.

Further selections of leeks resistant to " White tip," caused by *Phytophthora Porri* are being made.

DISEASES OF MINT.

Rust.

Treatments. In last year's report experiments were recorded which showed that complete control of the oecidial stage of mint rust, caused by *Puccinia Menthae*, could be obtained by dipping the runners in water at temperatures from 105 to 115°F. for ten minutes.

In 1936, a further test of this treatment was carried out in mid-February, to find whether it would still be effective at this late date, since our observations had led us to suppose that by that time the mycelium of the rust is present in the shoots. The results are summarised in Table II. It will be seen that there was complete control of the rust by the treatment. No injury, moreover, was apparent.

TABLE II.

Mint Rust Trial 1936.

Runners taken up and treated, February 18th, 1936, and planted immediately.

Treatments.	*No. of Rusted Shoots on Equal Beds of Three Strains of M. Villoso-nervata.*		
	A.	B.	C.
Control	21	5	16
Runners washed	11	1	5
Runners washed and dipped in water at 110°F. for 10 minutes	0	0	0

A bed of *Mentha cordifolia* was also forced and no rusted shoots appeared. The variety, however, was useless for market purposes.

Biology of the Rust. Satisfactory infections have now been secured by placing teleutospores amongst the bud scales of "treated" runners. These will be described when the disease is fully dealt with in a final paper.

In the outside beds in 1936 the uredospore stage was entirely absent from strains of the following varieties :—*M. niliaca nemorosa, M. cordifolia, M. citrata, M. crispa, M. rotundifolia, M. rubra.*

DISEASES OF ONIONS.

White Rot.

Several trials of organic mercury dusts have been laid down for the control of white rot, caused by the fungus *Sclerotium cepivorum.*

DISEASES OF PARSNIPS.

" Canker."

A type of " canker " entirely due to eelworm infestation is described in another paper in this Report by Dr. C. L. Walton (page 156), who distinguishes its symptoms from those of the types of canker reported by us.

DISEASES OF PEAS.

Pythium Foot Rot.

An unusual disease of peas was observed in the Bromham market gardening area of Wiltshire early in July. At that time large patches of plants were dying off, the bases of the stems being water-soaked, and the leaves yellowish and wilted. Examination of the stem bases showed extensive hyphae and oospores of a *Pythium.* The fungus has been got into pure culture and has been identified as a strain of *P. ultimum* Trow, while the symptoms of the disease have been reproduced in inoculations. It had been previously stated by growers in this area that if peas were not given adequate rotation the crop tended to be a failure. It may be noted that foot rot caused by *P. ultimum* is considered to be one of the worst diseases of peas in New York State, where it appears to be of much greater importance than that caused by *Fusarium Solani* var. *Martii.*

Fusarium Foot Rots.

Detailed work on the foot rot caused by *F. Solani* var. *Martii* and possibly by other *Fusaria* is being carried out by Mr. D. L. G. Davies, a postgraduate student.

Pea "Sickness."

Trials on the control of pea and potato "sickness," associated with the eelworm *Heterodera Schachtii*, are reported elsewhere in this Report in conjunction with Dr. C. L. Walton (page 149).

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THE EFFECT OF NITROGENOUS FERTILISERS ON POTATOES AFFECTED WITH POTATO "SICKNESS."

By C. L. WALTON, L. OGILVIE and C. J. HICKMAN.

In the Long Ashton Annual Report for 1935, experiments were described which appeared to indicate that the good effects following the application of heavy dressings of calcium cyanamide to potato "sick" land are attributable, not to any marked lethal effects on the eelworms (*Heterodera schachtii*) concerned, but to the restoration of certain essential chemicals, in this particular experiment apparently nitrogen, to the sick plants.

In 1936, further experiments were carried out in order to elucidate: (1) whether dressings of sulphate of ammonia in amounts equivalent to those of calcium cyanamide previously employed can bring about normal yields; (2) whether smaller and more economically practicable dressings are effective; (3) whether the number of cysts on the roots is decreased by any of these dressings; (4) whether the dressings have any deleterious effects on the cooking qualities of the tubers; (5) and whether the nitrogen content of the mature foliage is related to eelworm effects and is increased by the dressings.

Experimental.

Description of Trial. A field trial was laid down on heavily infested ground at Bromham, Wiltshire. The land bore a heavily infested crop of "Majestic" potatoes in 1935.

The lay-out of the trial is given below (Fig. 1).

FIG. I.

PLAN OF POTATO "SICKNESS" TRIAL AT BROMHAM, WILTS. 1936.

N	100 ft.	120 ft.	120 ft.	120 ft.	120 ft.	120 ft.
30 ft.	1a Control	2 Sulphate of ammonia at 3 cwt. per acre.	4 Calcium cyanamide at 10 cwt. per acre.	6 Sulphate of ammonia at 3 cwt. per acre.	8a Control.	9 Calcium cyanamide at 10 cwt. per acre.
	1b	3 Calcium cyanamide at 3 cwt. per acre.	5 Sulphate of ammonia at 10 cwt. per acre.	7 Calcium cyanamide at 3 cwt. per acre.	8b	10 Sulphate of ammonia at 10 cwt. per acre.

The area of each small plot was approximately one-twentyfourth of an acre, excepting Plot 1, which was slightly smaller than the others. An allowance is made for this in comparing the crop weights detailed below.

Treatments. A light basal dressing of dung and potash was applied to the whole plot previous to the applications of the experimental nitrogenous fertilisers, which were applied at the end of March.

Plots 2 and 6 each received 14 lb. of sulphate of ammonia (3 cwt. per acre); plots 5 and 10 each 47 lb. of sulphate of ammonia (10 cwt. per acre); plots 3 and 7 each 14 lb. of calcium cyanamide (3 cwt. per acre); and plots 4 and 9 each 47 lb. of calcium cyanamide (10 cwt. per acre). Plots 1 and 8 received only the basal dressing.

"Majestic" potato tubers were planted at the end of April, using approximately 500 tubers per plot.

Results.

Appearance of Plants. The plots were examined in detail on July 29th. On that date two categories of plants could be differentiated: (1) apparently diseased plants which were less than 1 ft. high, with spindly, slightly rolled leaves, the lower ones becoming yellow, and from which the flowers tended to fall off readily; (2) apparently healthy plants which were more than 1 ft. high, had normal, bright green foliage and were flowering profusely.

The percentages of diseased plants in the various plots are indicated in the composite table (Table I). 500 plants were counted in each case.

Cyst numbers. Counts were made of the numbers of *Heterodera* cysts on roots of several apparently diseased plants collected from each plot on July 29th. The method was as follows. The plants were dug very carefully. Roots bearing cysts were removed from the plants and cut up into 2 cm. lengths. These lengths were examined under a binocular microscope and the number of cysts counted, first on one side of the root and then on the other. Forty root lengths, each 2 cm., were examined from each plot. The results are given in Table I. Unfortunately the roots from plots 2 and 3 were examined some time after digging, with the result that most of the cysts had fallen off and further samples obtained were useless for the same reason.

TABLE I.

RESULTS OF POTATO "SICKNESS" TRIAL, BROMHAM, WILTS. 1936.

	Plot. No.	*Treatment.*	*Percentages. of Plants apparently diseased.*	*Cyst Counts on 80cm. Lengths of Roots.*	*Total Weights in lb.*	*Calculated Weight per Acre in lb.*	*Percentage of total Nitrogen in young Leaves.*		*Silica-free Ash (Carbonate) in young Leaves (expressed as % Dry Matter).*	
							Apparently healthy Plants.	*Apparently diseased Plants.*	*Apparently healthy Plants.*	*Apparently diseased Plants.*
			A	B		C	D	D	E	E
Block A	1	Control	50.1 (1)	279 (2)	487	11,688 (1)	0.9065 (2)	0.7659 (3)	10.03 (2)	11.04 (2)
	3	Calcium cyanamide (3 cwt/acre)	17.8 (4)	—	974	23,376 (5)	0.8826 (1)	0.6134 (1)	—	11.28 (4)
	2	Ammonium sulphate (3 cwt/acre)	31.4 (2)	—	736	17,616 (3)	0.9327 (3)	0.7319 (2)	10.78 (4)	11.08 (3)
	4	Calcium cyanamide (10 cwt/acre)	29.4 (3)	364 (1)	658	15,792 (2)	1.0024 (4)	0.8024 (4)	9.89 (1)	11.93 (5)
	5	Ammonium sulphate (10 cwt/acre)	15.0 (5)	255 (3)	780	18,720 (4)	1.0110 (5)	0.8380 (5)	10.46 (3)	10.54 (1)
Block B	8	Control	70.9 (1)	342 (3)	283	6,792 (1)	0.8860 (1)	0.7856 (1)	12.44 (3)	10.97 (2)
	7	Calcium cyanamide (3 cwt/acre)	49.8 (4)	295 (4)	560	13,440 (3)	0.9148 (2)	0.8081 (2)	13.53 (5)	11.04 (3)
	6	Ammonium sulphate (3 cwt/acre)	64.0 (2)	575 (1)	634	15,216 (4)	0.9768 (3)	0.8256 (3)	11.11 (2)	10.20 (1)
	9	Calcium cyanamide (10 cwt/acre)	63.4 (3)	467 (2)	489	11,736 (2)	0.9977 (4)	0.8550 (4)	12.70 (4)	11.06 (4)
	10	Ammonium sulphate (10 cwt/acre)	8.6 (5)	269 (5)	682	16,368 (5)	1.1150 (5)	0.9367 (5)	10.78 (1)	11.18 (5)

A = Order of Plots (greatest to least number of plants diseased).
B = ditto (greatest to least number of cysts).
C = ditto (least to greatest crop weights).
D = Order of Plots (least to greatest amounts of nitrogen).
E = ditto (least to greatest weights of ash).

Crop weights. The tubers from each of the plots were weighed. The results are given in Table I, expressed as total weight per plot in pounds, and as calculated weight per acre in pounds. The weights given for plots 1 and 8 are the average of the weights of the two halves of each double plot.

According to the grower the normal crop weight from potatoes growing on uninfested land in the same area as the trial plot is about 9 tons (20,160 lb.) per acre.

Cooking Tests on Tubers. Tubers from the control plots and from the various treated plots were boiled in the ordinary way on November 24th, 1936. All cooked well, there being no difference in time of cooking, flavour or consistency of the various samples.

In a further cooking test on February 22nd, 1937, the boiled potatoes from the sulphate (10 cwt.) plots were slightly inferior in texture to those from the other plots.

Plant Analyses. Samples of shoot tips from both healthy and apparently diseased plants were collected from all plots on July 17th, 1936, and determinations made of the total ash content and total nitrogen content of the leaves of these, using Ranker's (2) method to include nitrate nitrogen, to discover any possible differences occurring between healthy and diseased plants and between plants receiving different manurial treatments.

All determinations were carried out in duplicate. The results for nitrogen are expressed in Table I as percentages of fresh weight and for ash content as percentages of dry matter.

Table II gives the average percentage of total nitrogen in healthy and apparently diseased plants respectively from all the plots.

TABLE II.

AVERAGE PERCENTAGE OF TOTAL NITROGEN IN LEAVES OF SHOOT TIPS FROM ALL PLOTS.

Apparently healthy.		*Apparently diseased.*	
Average Percentage of Nitrogen.	Standard Error of Mean.	Average Percentage of Nitrogen.	Standard Error of Mean.
0.9515	0.021	0.7928	0.022

The difference between the mean percentage of nitrogen in healthy and diseased plants is significant.

Discussion.

After each column in Table I there is given in brackets a figure indicating the order into which the plots fall. The method of numbering allows of easy comparisons between the various columns in the table.

Growth of Plants. The growth of the plants was more luxuriant in the half of the field designated block A than in the half block B, and the factor involved appears to be one of fertility apart from eelworm infestation. Thus although plot 10 had much the lowest percentage of diseased plants the crop yield was not correspondingly great and only ranked as fourth among the plots.

Crop Weights. The greatest crop weights were obtained as a whole from the apparently more fertile block (A). Here, and also in block B, cyanamide (10 cwt.) gave a smaller yield than cyanamide (3 cwt.), a result which requires further investigation, but which might suggest a toxic effect to the plants on the part of the chemical at the higher rate or merely reflect some variable soil factor. On the sulphate of ammonia plots the yields varied directly with the rates of the dressings.

Percentages of apparently Diseased Plants. In both blocks, A and B, the percentages of apparently diseased plants decreased in the following order: control, sulphate (3 cwt.), cyanamide (10 cwt.), cyanamide (3 cwt.), sulphate (10 cwt.). Whilst in the case of the sulphate plots the amounts of nitrogen applied are correlated inversely with the expression of disease symptoms, this does not hold for cyanamide, where the 3 cwt. dressing is associated with a lower percentage of diseased plants than the 10 cwt. rate.

Taking the two blocks A and B together, it is seen that the largest percentages of symptom manifestations were in the apparently less fertile block B, except in the case of the sulphate (10 cwt.) plot, where the percentage reaches a very low figure.

As a whole the crop weights suggest an inverse correlation with the percentages of apparently diseased plants, but the relationship cannot be pressed too closely.

Cyst Counts. As far as the cyst counts are available there does not seem to be any clear correlation between them and the other results obtained, and there is no evidence of any reduction of the eelworm population from the nitrogenous dressings even though higher yields were obtained.

Chemical Data. Inspection of the ash data shows at once that there is no correlation between these and percentages of diseased plants or cyst counts. In block A, the apparently diseased plants showed higher ash contents than the apparently healthy plants for each treatment, whereas in block B the reverse held except for plot 10.

In the case of the nitrogen percentages, however, the important fact is brought out that in every plot the apparently healthy plants had higher nitrogen percentages in the young leaves than the apparently diseased plants. This result strongly suggests that the eelworm attack interfered with the nitrogen metabolism of the plants.

The nitrogen percentages throughout the plots in block B increased with the dressings of nitrogen for both healthy and diseased plants, but in block A there are three cases, on plots 2 and 3, where the values are below those for the control plot No. 1. It should also be noted that comparable values for nitrogen in block B were generally higher than those in block A, although the crop weights in block A are higher than those in block B. This indicates that the superior fertility in block A was not due to a higher nitrogen status in the soil of the block.

Blenkinsop (1), working on potato " sickness " in Devon and Cornwall, has demonstrated that in that area the symptoms are associated with a low potash/phosphate ratio in the soil. He considers, however, that low nitrogen ratios may sometimes be involved. The present case seems to be one in which there is a definite association between " sickness " and a defect in nitrogen metabolism.

Conclusions.

The following conclusions may be drawn from the data :—

1. The yields of potatoes over the " sick " soil area were increased by both nitrogenous fertilisers, generally very appreciably.

2. The yields as a whole were inversely proportional to the percentages of apparently diseased plants, but were not correlated with the numbers of cysts on the roots.

3. In every case the apparently healthy plants contained higher percentages of nitrogen in the young leaves than the apparently diseased plants, indicating that the eelworm attack had interfered with the nitrogen metabolism of the plants.

4. There was no correlation between the ash contents of the young leaves and percentages of apparently diseased plants or cyst counts.

5. A very slight adverse effect on the cooking quality of the tubers was produced in tests in February, 1937, by the sulphate (10 cwt.) treatment.

Acknowledgments.

The calcium cyanamide was supplied free of charge by Messrs. Shaw, Scott & Co., to whom thanks are due.

Dr. T. Wallace very kindly gave valuable advice on the conduct of the trial and in the interpretation of the data.

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ANGUILLULINA DIPSACI (KÜHN) AS A CAUSE OF PARSNIP "CANKER."

By C. L. WALTON.

Introduction.

Parsnip "Cankers" in the Bristol Province.

During the progress of the Survey of Vegetable Diseases of the Evesham District carried out by Mr. L. Ogilvie and co-workers. several types of parsnip canker have been differentiated, which may be enumerated as follows :—

1. A proportion of the so-called "cankers" appears to be entirely due to injury by the larvae of the Carrot Fly (*Psila rosae*). In these cases the "crown" of the root bears rust-coloured lesions, permeated by the borings of the larvae.

2. Some cases are undoubtedly due primarily to growth cracks, as suggested by Cotton (1) and Ministry of Agriculture (2), and by Stirrup and Roebuck (3). Such cracking was found by Stirrup and Roebuck and also by Ogilvie and Mulligan (4), to take place especially in badly shaped varieties, and to be very slight in the best, long tapering sorts.

3. Ogilvie and Mulligan (5 and 6) found in the Bristol neighbourhood a distinct type of canker which was characterised by dull, greenish-black lesions near the top of the crown. An *Ascochyta* isolated from these produced the typical symptoms on inoculation.

4. The type described in the present article is distinct from the three types already enumerated in the following particulars :

(*a*) It is often apparent when the "roots" are quite small.

(*b*) It is accompanied by characteristic symptoms on the leaves and leaf stalks.

(*c*) The affected areas on the crown of the mature roots are much swollen.

During the examination of this last type considerable numbers of eelworms were found to be present, and specimens were sub-

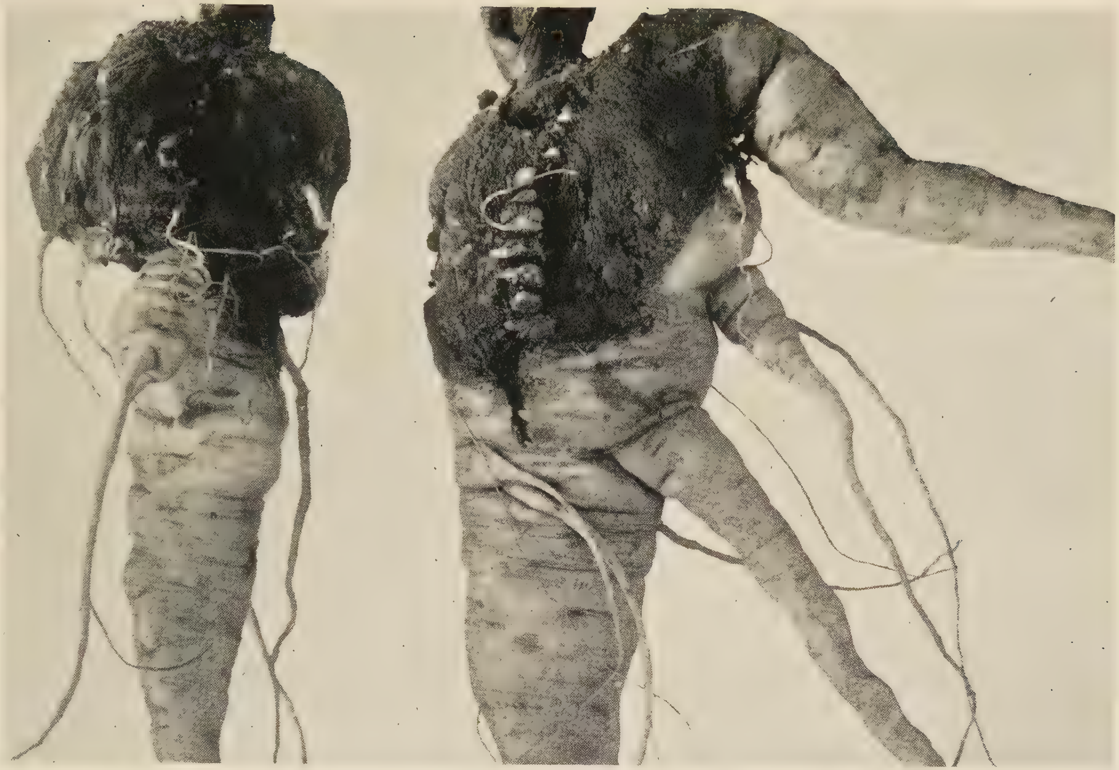

FIG. I. Parsnips showing typical effect of infestation with *Anguillulina dipsaci*.

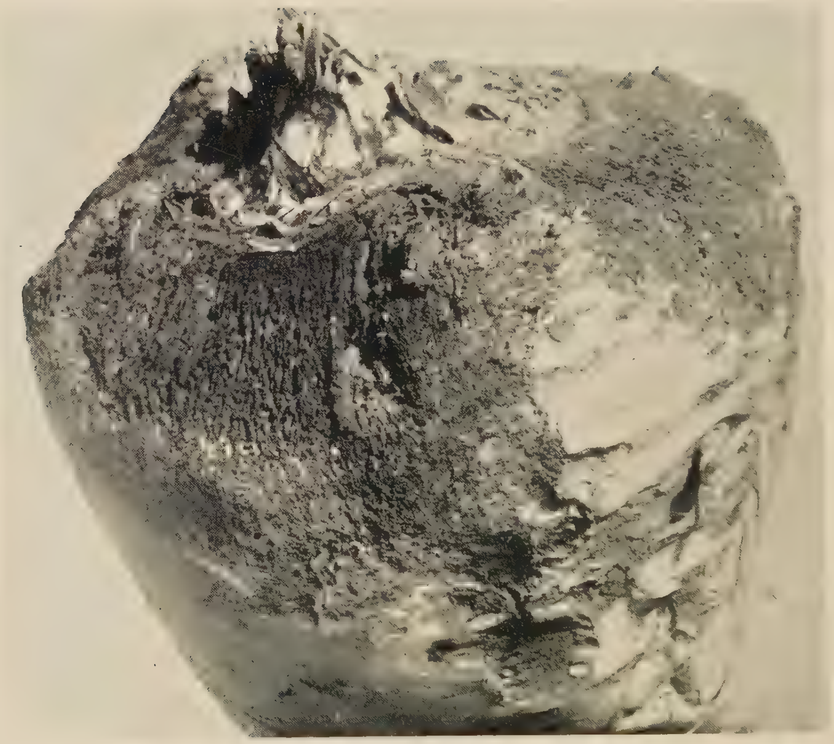

Fig. II. Parsnip grown in infested Onion bed near Bristol showing lesions on "crown."

mitted to Dr. T. Goodey of the Institute of Agricultural Parasitology. Dr. Goodey replied that the diseased tissues were heavily infested with *Anguillulina dipsaci*, and stated that "this is the second time only that this parasite has been found on this host, the previous one being on parsnips grown close to Biggleswade, Beds." Dr. Goodey further suggested that "since onions are commonly attacked by *A. dipsaci* in Bedfordshire, I surmise that the parsnips followed onions." This was confirmed.

The general conditions set up by severe infestations of the eelworm are shown in Fig. 1.

In addition to the spongy discoloured areas there shown, lesions containing the parasite also occur on the leaves and petioles, the leaves showing marked curling and stunting, whilst the worms are most abundant in the slightly discoloured tissues bordering the lesions.

Experimental.

Three centres A, B and C, were selected for experiments in 1936, two (A and B) where field trials could be carried out under especially favourable conditions, and C for purposes of observation. At all three centres the soil was of a heavy texture.

Centre A. Oldland, near Bristol.

This is a market garden, much of which is so heavily infested with *A. dipsaci* that onion crops can no longer be successfully grown. The grower had drawn attention to this in 1935, and at the writer's suggestion a 1/16th acre plot was sown with onions on March 12th, 1936. The variety was Bedford Champion which had suffered very severely from typical onion "bloat" on this bed in 1935. The grower, who had worked this ground for many years, stated that parsnips had not been grown on this bed during that period. Accordingly a double row of parsnips was sown across the centre of the onion plot.

By June 19th, 60% of the onions had been ruined, but the parsnips were not visibly affected. Parsnips lifted on September 29th, however, showed 40% to have developed more or less well marked lesions—although these were not as severe as in typical cases from the Evesham area. A photograph of one of these roots is shown in Fig. II. *A. dipsaci* occurred freely in the tissues.

Centre B. Pebworth, near Evesham.

On this market garden land some areas were so heavily infested as to render parsnip growing quite unsuccessful.

At the writer's suggestion the grower put down a large plot of parsnips on land which had been badly infested during 1934, and also sowed a strip of onions a yard wide running up the centre of the plot. Both crops were put in on April 6th. The grower stated that onions had not been grown on this plot within his memory.

By July 23rd, 75% of the onions had developed typical symptoms of " bloat " and 50% of the parsnips were visibly affected.

At each of the above centres A and B the beds described were divided into three more or less equal areas, and to two of these dressings of calcium cyanamide were applied at the rates of 5 and 10 cwts. per acre respectively a fortnight prior to the sowing dates, the third area being left without treatment.

In neither case was there any difference in the degrees of infestation due to the cyanamide treatments, although the surviving plants on the treated plots showed evidence of nitrogenous stimulation.

Centre C. Pebworth (about ½ mile from Centre B).

This is an extensive market garden, growing particularly excellent crops of both parsnips and onions. No trial was laid down here, but the grower drew the writer's attention to the following facts :—

A plot of parsnips 1/8th acre in extent was showing small isolated areas of typical eelworm " canker " and had been cropped with onions in 1935, which had then shown similar small areas of " bloat." This was also the first onion crop for at least twelve years.

On an adjacent and similar bed the cropping has been as follows :—

1933.	Parsnips.	An excellent crop, but a few odd specimens of " canker."
1934.	Onions.	A few occasional spots of " bloat " at one end.
1935.	Peas.	
1936.	Onions.	An excellent crop, but again with the same limited areas of " bloat."

Conclusions.

1. Several distinct types of parsnip "canker" can be differentiated.

2. A type distinguished by characteristic root and leaf lesions is associated with infestations of the eelworm *Anguillulina dipsaci.*

3. Field trials and observations in 1936 showed that typical symptoms of infestation of this eelworm developed in onions when grown after infested parsnips and *vice versa.*

4. Dressings of calcium cyanamide at the rate of 5 and 10 cwts. per acre failed to effect any reduction in infestation.

Acknowledgments.

The writer wishes to thank the growers concerned for their co-operation in these trials.

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THE EFFECT OF SPRAYING METHODS UPON THE COST OF APPLYING FRUIT TREE WASHES.

By T. SWARBRICK.

INTRODUCTION.

The post war period has witnessed a rapid and almost revolutionary development in the methods of fruit tree spraying in this country. This development has been initiated by the need of an expanding industry for more rapid, efficient and economical methods of pest and disease control. The development has been particularly marked not only in the design of spraying machinery and its necessary accessories, such as spray guns, lances, nozzles, hose connections, etc., but also in the organisation of men and machinery into a " spraying unit." This latter development has taken two very definite lines, one towards the so-called " Mobile " method whereby the machinery and men are taken through the orchard, spraying as they go, and the other towards the installation of a permanent underground pipe system, the wash being pumped by a large " Central " pumping unit.

In spraying machinery the developments have been in the direction of increased working pressures, greater adaptability, the use of non-corrosive metals, an improvement of the pump packings, and the introduction of more sensitive pressure regulators. English made spray guns have only been introduced within the last ten years but they are now second to none, and along with the many improvements in nozzle design that have also taken place during the same period, English made spraying equipment is now rapidly approaching the efficiency of its American counterparts.

The above developments in methods and machinery have proceeded alongside the introduction of new and improved fungicidal and insecticidal materials. An increasing knowledge of the life cycle of the several pests and diseases has in many cases called for more rapid methods of spray application. Moreover, it has now been shown that in the aggregate the cost of pest and disease control is one of the largest single items of expenditure in fruit production.

A careful analysis of this expenditure should provide a basis for the development of more economical methods.

It cannot be denied that, with an increasing demand for perfect fruits and the dangers arising from the localization of fruit production within certain well-defined areas, spraying, as a method of pest and disease control, will assume an even greater importance in the future. Like cultivation, it is an operation which is carried out from three to five times during the course of each growing season, and any advantage that can be gained either in economy, speed, or efficiency of application may represent a considerable saving during the course of a year. No apology is therefore offered for the emphasis that will be laid in this paper upon practical details.

Spray applications differ in their objectives and spraying must be organised accordingly. Some sprays for example are intended to leave a protective covering, others to give a kill by direct contact. The more recently developed " omnibus " washes are intended to serve both these functions. Applications of summer washes must often be made within very narrow time limits, four or five days at most, and labour and machinery must be organised to do this. From a wide experience of fruit tree spraying in this country, it is suggested that the most frequent cause of inadequate pest and disease control in commercial fruit plantations is the lack of adequate facilities and organisation to meet the essential requirements. The expert advice of the pathologist is often of little or no avail since it cannot be carried into effect by existing methods and machinery.

It cannot be too strongly emphasised that there is no " best method " of spraying which is uniformly applicable to all fruit farms. Each field has its own particular problems arising from such factors as the predominant kind of fruit, *e.g.* apples, plums, or bush fruits, the availability of water and the relative intensity of the methods employed. Each spray application requires its own special modification of the general procedure. In this connection, it is the grower himself who occupies the " key " position, since the ultimate efficiency of the spraying unit depends very largely upon his skill and judgment. Management is undoubtedly an important factor since, with good management, a less efficient machine may be made to give better and more economical results than the poor management of a good machine.

A discussion of spraying costs is admittedly difficult, and can only be undertaken at the risk of serious misunderstanding and misapplication. With the best will in the world it is impossible to compare spraying costs unless an accurate and comprehensive system of book-keeping has been followed. This point is emphasised since the writer has several times attempted to cost the spraying of commercial fruit farms without much success, except once, where the grower was following an accurate method of book-keeping and was able to furnish most of the details required. There are, no doubt, many other growers who have the necessary data, and the writer would welcome an opportunity of examining such records in order to widen his experience and extend the scope of his investigations.

The present contribution is based upon eight consecutive seasons work at Long Ashton, viz. 1928 to 1935 inclusive. The particular aspect of spraying costs discussed is that of the cost of making a spray application. the total cost of spraying not being discussed.

EXPERIMENTAL.

As early as 1925 spraying problems were made the subject of special investigation at Long Ashton, and the results of some of this work were published in the Station Annual Report for 1929 (1). From 1928 onwards there has been continuous development of this work along the lines of both systematic pathology and spraying technique.

Owing to the experimental nature of the general plantations at Long Ashton, records are naturally more complete than those usually available on commercial fruit farms where recording facilities are usually very limited. All plots are numbered and are sprayed separately, and since 1928 systematic records have been collected for all spraying operations. The following are the data available for each spray application :—

1. Total number of men employed and their respective duties. (Total man hours of labour.)
2. Total man hours spent actually applying wash to the trees. (Nozzle hours.)
3. Man and horse hours spent moving pipes, etc. (General preparation.)
4. Man and horse hours spent carting water. (Carting water.)
5. Man and tractor hours spent. (Tractor hours.)
6. Time lost by breakdowns with a record of the causes.
7. Kind of wash used, giving details of its composition, etc.

8. Number of gallons of wash used.
9. Amount of petrol and oil used by engine.
10. Method of application. *e.g.* Knapsacks. Headland (Semi-portable) or Mobile.
11. Date of application, notes on state of ground, wind velocity, whether the application was intentionally light or heavy, the "cover" obtained and in fact any notes likely to be of use for future reference.

The above data for each plot on the Station farm can be supplemented with the records of crop yield. quality of fruit produced, etc.

The data discussed have been obtained from such widely different equipment as hand-operated knapsacks, a medium-sized power outfit working at 200 lbs. pressure to the square inch, and a large, mobile. high pressure plant, capable of delivering 20 gallons per minute at a working pressure of 400 lbs. per square inch. Unfortunately they do not include experience with a central pumping system. A similar study of the operating costs of such systems would be of great value at the present time owing to the more extended use of such systems on commercial fruit farms.

The Plots.

While the above information is available for all the plots at Long Ashton, only certain of them have been selected for detailed examination. The plots selected are typical blocks of trees either with or without an interplant, and typical plantations of black currants without top fruits. In order to facilitate comparisons of these data with those of other investigators, a detailed description of the selected plots is given.

Plot 2. Area 3½ acres. Comprising one hundred 20-year-old half standard plum trees planted at 15 feet apart in rows 35 feet apart. The average size of these trees is from 12—13 feet high with a spread of from 12 to 14 feet. The alleyways are fully planted with gooseberries and red currants at 5 × 5 feet. The presence of these bush fruits makes movement on this plot very difficult and all spraying has to be done by the stationary method of laying out long lengths of pipe. The water for spraying is obtained from a low pressure ½ inch pipe at one side of the plot.

Plot 4*B*. Area 1 acre. Comprising 1,800 black currant bushes planted in the winter of 1928-29 at a distance of 6 × 5 feet. They were one year fruiting bushes during the summer 1930. Varieties mostly Boskoop, Baldwin and Seabrook. All bushes made good growth so that by 1933 it was impossible to get even a horse hoe between them. Water for spraying is as for Plot 2. The plot is sprayed by making three " positions " of the machine and using long lengths of rubber hose.

Plot 7 *B*. Area 1¾ acres. Comprising 96 trees each of the apple varieties Worcester, Lane's and Bramley on a range of vegetatively-raised rootstocks and planted in the winter 1919-20 at 15 × 15 feet. These trees have all made excellent growth, except the eight trees of each variety on M. IX. In the winter of 1930 half the Bramley trees were removed in order to allow reasonable development of the remainder. Pruning has been relatively light on all trees. Trees were in clean cultivation with an intercrop of red currants up to the winter of 1928-29, when the currants were removed and a grass seeds mixture was sown over the whole plot. Water for spraying has to be carted a distance of 600 yards.

Plot 8 *A*. Area 2 acres. Comprising a total of 363 trees of the two apple varieties, King Edward VII and Allington Pippin. These trees were planted in the winter of 1919-20 at 15 × 15 feet apart. Clean cultivation has been maintained throughout and the trees have been touching in all directions since 1930. Very light pruning was practised up to the winter of 1935-36, when the trees of Allington Pippin were heavily pruned. For our present purposes this particular block of trees may be regarded as a typical fully mature plantation of bush apple trees on Type I. The site is a gentle slope which presents a little difficulty when very wet. The water for spraying has to be carted a distance of about 300 yards.

Plot 18. Area 4½ acres. Comprising 750 plum trees planted at 16 × 18 feet in the winter of 1925 with an interplant of gooseberries in the tree rows only. These trees comprise a plum rootstock and variety trial and in consequence there is marked variation in tree size. Since the trees of Blaisdon Red are very large and form at least one-tenth of the total number of trees on this plot, they compensate for the smaller trees of such varieties as Purple Pershore. Clean cultivation has been maintained throughout. It should be stressed that during the period under review these trees have been undergoing a rapid development in size, particularly during the period 1931-36. Water for spraying has to be carted a distance of approximately 800 yards, and owing to the nature of the soil on this plot movement may be very difficult during wet weather. The plot may be regarded as a typical, developing, mixed plum plantation.

Plot 21. Area 6½ acres. Comprising 300 young standard apple trees planted in 1929 on a diagonal plant at 30 feet apart. These trees have a row of black currant bushes running in the tree rows *across* the plot. The alleyways between the black currants are therefore 15 feet wide. During the period covered by this report the black currants have undoubtedly been of major importance on the plot and the spraying of the standard trees has often been carried out at the expense of a considerable wastage of wash owing to drift. Water for this plot has to be carted a distance of about 300 yards. The site is a fairly steep slope which is very difficult to negotiate during wet weather in winter.

Plot 22. Area 5 acres. This plot comprises the same kind of trees as those found on plot 21, but without the interplant of black currants, and the trees are planted in grass sod. Owing to the grass sod culture the size of these trees is slightly less than those on plot 21. Water has to be carted a distance of about 6-800 yards. The grass sod facilitates easy movement on this plot at all times of the year.

Spraying Methods.

Before proceeding to a detailed examination of the data, the following explanatory notes relating to spraying methods are necessary. In the winter of 1927-28 knapsack sprayers were used. The mode of operation was to place tubs of wash at convenient places on the plot, the operators coming to them in order to refill. The futility of this method was obvious and a new 3½ H.P. machine was purchased in the spring of 1928. This machine had a maximum output of approximately 7 gallons per minute at a working pressure of 250 lbs. per square inch. The machine was mounted on a triangular frame and had two separate tanks, each holding approximately 40 gallons. When purchased, this machine was of reasonably well advanced design, and at that time was regarded as a " high pressure " sprayer. At first the relatively high working pressure gave considerable trouble with burst pipes and blown unions, and while the easier course out of these difficulties was to reduce the working pressure this was not resorted to and the difficulties were finally all surmounted. From 1928 to 1930 this machine was used in the orthodox manner, *i.e.* as a " stationary " or " semi-portable " unit placed at a convenient position alongside the plot, water and spray fluids being carted to it, and the spray fluids led away under pressure either in overground steel mains or in long lengths of half inch rubber pipe. A careful analysis of the working of this system was made in 1930 and this suggested that too many men were employed in relation to the " output " of the machine, and too much time was used in moving the machine and in picking up and re-laying the pipe system. In fact, spraying by this method was the signal for a complete disorganisation of the normal work of the plantations, since it required the services of at least five workmen and all the available horses. In consequence, during the period 1930—1932 numerous attempts were made to reduce the labour requirement by using the above machine as a " mobile " unit. By this method the spraying machine was taken from tree to tree by means of either horses or tractor. This method of spraying, of course, required the continued use of either horses or a tractor, but as will be emphasised later it only required the use of two men other than the tractor driver.

The early attempts at mobile spraying showed that the success of the method was determined by the adapability of the spraying machine for this purpose. The first machine to be used in this way was easily overturned and only carried a maximum of 80 gallons of wash, an amount which in practice was reduced to 55—60 gallons owing to the risk of loss by splashing. After numerous attempts to obtain a suitably designed machine, *i.e.* one which combined a large output, a high working pressure and a large tank capacity with a minimum of weight and a small turning radius, a large 8 H.P. 20 G.P.M. plant was purchased in spring 1933. It is the effect of the introduction of this machine upon the spraying time and costs that is specially discussed in this present paper.

Spray Guns and Lances.

The subject of spraying machine accessories is one which requires separate treatment in order to deal adquately with the many interesting points that are involved. The main issue is between the use of spray guns as against " fixed " nozzles. Without attempting to discuss the matter, it may be stated that as the result of a wide experience of spraying in the windy conditions that usually prevail throughout the West-Midlands, spray guns have been found more satisfactory than any of the fixed nozzle types so far available. From 1928 to 1932, that is during the period of the small 3½ H.P. machine, an American spray gun was used as being the best then available. Since 1933, English made spray guns have been used entirely, and while the merits of fixed nozzles have not been neglected, these have not been used in the trials reported herein. It is hoped at some future date to compare the relative merits of spray guns as against fixed nozzles.

Costing Methods.

The present discussion is confined to the cost of making a spray application, in terms of labour, horse and tractor hire. It is realized that from the commercial standpoint the total cost of spraying is the more important consideration, but it is pointed out that total cost may be determined to a very large extent by the cost of the wash used. This in turn is affected both by the cost of the concentrate and by the amounts used per acre. At a Research Station, both the amounts of any wash used and its nature are determined by experimental rather than commercial considerations. Reference to the tables shows that on certain plots the amount of wash used has varied considerably from year to year, due almost entirely to experimental considerations. The costs of application, as set out in the several tables, refer to the quantities stated, without reference to whether these are greater or less than normal commercial practice.

Another item of expenditure which has an influence upon total spraying costs is the overhead expense of running the spraying machine. Since the costing for this item also involves a number of points it has been thought desirable to confine the present paper to the effect of methods upon the time taken to cover a unit area of trees, and the cost of making the spray application. Costs relating to the use of spraying machinery are now being prepared and will be published in due course.

All labour has been charged at the uniform rate of 9d. per hour, except the horseman and the tractor driver, where wages are included in the figure charged for horse and tractor hire. The above charge of 9d. per hour may be slightly in excess of the ruling rates in other districts, but they may be regarded as reasonable for this class of work, and are put at this level so that there shall be no under-estimation of costs.

The tractor is charged at the rate of 4/- per hour for the actual time it is employed on the particular plot. This charge is considerably in excess of the usual charge of 2/- to 2/6 per hour, but is intended as an inclusive figure. It is in fact based on several years experience and costs of both Fordson and Caterpillar tractors, and includes the cost of the driver, all running expenses, service charges for oiling, etc., and a fair share of depreciation, repairs and renewals. This figure is also on the generous side and on a large commercial holding might be reduced to about 3/- per hour.

Horse hire has been charged at the rate of 2/- per hour for all time actually spent on the work. Here again the figure includes the driver's wages and a charge for maintenance, Sunday feeding, etc.

General Notes.

Attention is called to the following points. The figure for total labour hours includes all labour except that of horseman and tractor driver, who are charged separately. In the present case this figure also includes the foreman's time and, since the work is experimental, it requires careful supervision and the foreman's time is thus considerably in excess of the normal requirements of a fruit farm. In considering labour costs this fact should be kept in mind. The total number of men employed on the work is set out in the tables, and it should be noted that this figure *includes* the horseman or the tractor driver. In order to bring out the proportion of the total time spent in preparation, moving the pipe system, etc., as against that spent actually applying the wash to the trees, the figure for total labour hours has been dissected as follows :—

(*a*) Time spent preparing the machine, laying out pipes, etc.
(*b*) Time spent filling up, which time includes carting water.
(*c*) Time spent actually applying the wash, *i.e.* nozzle hours.

RESULTS.

The data selected for examination are presented in Tables 1—8, and refer to winter washing only.

Since plots 8A and 7B are typical blocks of fully grown, 15-year-old bush apples on a semi-dwarfing rootstock, it is most convenient to begin with a detailed examination of the data relating to these plots. Reference to Tables I and II shows that for the 1928-29 spray application, semi-permanent steel mains and *short* lengths of rubber pipe were employed, whereas in the two following years the steel mains were discarded in favour of relatively *long* lengths of rubber hose. In 1932-33, the small 3½ H.P. machine was first used as a " completely mobile unit," being hauled in this case by a Fordson tractor. In subsequent years the large 8 H.P. machine was used on the mobile principle in conjunction with a " Caterpillar " tractor. It can be seen, therefore, that during the period covered by this examination there has been a development in technique and an increase in size and power of both spraying machine and tractor.

I. Spraying Mature Bush Apple Trees.

a. Effect of Spraying Method upon the Number of Men Employed.

An examination of the data given in Tables I and III shows that the *method* of making a spray application has a determining influence upon the total number of men which must be employed. During the years 1928 to 1931, when the semi-portable method was in use, a total of seven men was employed as follows: four men spraying, one man minding the engine and mixing wash, two horsemen. In practice, it was found that while one horse and cart could hardly keep the sprayer supplied with water two were more than sufficient. The horsemen were therefore called upon to give a certain amount of assistance moving the pipe system, etc.

In 1932-33 an attempt was made to use the 3½ H.P. machine on the mobile method. It was obvious that this machine was not designed for use in this way, but even so the method enabled the spraying crew to be reduced to five by the elimination of two of the nozzle men. These five men were employed as follows: two men spraying, one tractor driver, one horseman carting water, and one man mixing wash and minding engine, etc. This last man was necessary since the machine was not adapted for this class of work and was liable to stop, and the pressure release valve required careful watching.

From 1933 onwards, the use of a large 8 H.P. machine designed and equipped for mobile spraying enabled the total number of men employed to be reduced to three as follows: two men spraying and one man driving the tractor. From 1933 up to the present time, this spray crew has been responsible for the whole spraying operation, including the haulage of wash. This has been made possible by the large tank capacity of the spraying machine itself—240 gallons. Thus, one filling of the machine is sufficient for spraying about half an acre. Where necessary a "local" supply of wash is established by hauling 700 gallons of wash on to the plot by means of an old farm waggon fitted with a draw bar and loaded with two 350-gallon tanks.

This marked reduction in the number of men employed by the mobile as against the semi-portable method is in fact one of its important claims to consideration. It is increasingly evident that under present conditions spraying and other essential routine operations must be planned in relation to the quality and the amount of labour that is available. The mobile as compared with the semi-portable method liberates both men and horses for other essential occupations, and even if the method showed no monetary economy as compared with the semi-portable method it does show a marked economy in so far as man power and management are concerned. It will be realized that during the summer this saving in man power may be of very great importance, particularly on mixed fruit farms where the picking of soft fruit may coincide with the summer spray applications.

b. Effect of Spraying Method upon Labour Organisation.

It has been shown in the preceding section that the method of making a spray application determines the number of men required to form the spray crew and that by the mobile method this number is reduced to a maximum of three. The total labour hours spent on spraying these two plots for the years 1928 to 1935, excluding horseman or tractor driver, are as follows :—

	Semi-portable.					*Mobile.*		
	1928	1929	1930	1931	1932	1933	1934	1935
PLOT 8A	38	18	25	16	20	13	11	7½
7B	23	15	16	—	13	9	8	6¼

These figures show a marked decline over the period, the drop being particularly noticeable during the years 1933-35 after the introduction of the mobile method. Mobile spraying, therefore, shows a marked economy in total labour.

Considering next the figures for total nozzle hours, it will be remembered that this is the man hours spent actually applying wash to the trees. This figure when subtracted from that of "total man hours" given above gives the time spent in general preparation, moving pipe systems, filling up, etc.

The number of men employed handling spray guns is given in the tables. Under the mobile system in use from 1933 onwards the spray men never numbered more than two, whereas under the semi-portable system the number was four. The nozzle hours required to spray these two plots for the years 1928 to 1936 are as follows :—

	Semi-portable.					*Mobile.*		
	1928	1929	1930	1931	1932	1933	1934	1935
PLOT 8A	14	9½	11½	8⅔	8	3⅔	4¼	1⅓
7B	13	8	8	—	6	3⅙	3	2½

An examination of these figures shows that during the above period there has been a large reduction in the nozzle hours expended in spraying these plots. In the winter of 1928, for example, it took four men a total of 14 nozzle hours, or 3½ hours each, to spray plot 8A by the semi-portable method, whereas in the winter of 1935 the same plot was sprayed by two men with the mobile method in a total of 1½ nozzle hours, or ¾ hour each.

A reduction in nozzle hours occurred between the winters of 1932 and 1933. For plot 8A and 7B the nozzle hours fell from 8 and 6 to 3⅔ and 3⅙ respectively. This reduction marked the introduction of the large machine and the adoption of the mobile method. Under the semi-portable system of spraying in use from 1928 to 1931, the total nozzle hours required to spray plot 8A never fell below 8, whereas under the mobile system it has never exceeded 4¼ and has been as low as 1⅓. Two important advantages of the mobile method should be noted ; the first is the reduction in the number of men employed under this method, and the second is the fact that this reduced spray crew of three can " cover " this plot in approximately half the time taken by seven men using the smaller machine under the old method.

The above achievements have resulted from a combination of factors. In the first place there is the reduction in the number of men required since in mobile spraying only two, or at most three, spray men can be accommodated. In the latter case the third man must be provided with a " tower." In the second place, owing to the fact that in mobile spraying the men do not have to drag their pipe lines, they are relieved of a heavy physical burden and are thereby enabled to concentrate their energies upon the more important task of directing the spray fluid into its required position. When relieved of the burden of pulling the pipe system, it was found that any given spray man could effectively handle and " place " a much larger output of wash than under the semi-portable system. This led to a search for spray guns and nozzles capable of dealing with much larger outputs, and finally to the introduction of triple nozzle spray guns designed to deal with outputs up to 12 or even 14 gallons per minute. Clearly such large outputs require large and efficient pumping machinery, of sturdy, compact build yet of relatively light construction, points of extreme importance in the successful development of mobile spraying. It should be noted, therefore, that the mobile system provides a rapid means of spraying, provided always that a machine of suitable design and output is employed in conjunction with suitable accessories. It has been found by experience over a number of years that in mature plantations of top fruit trees, an output of from eight to twelve gallons per minute per man can easily be handled and properly placed under the mobile system, whereas under the semi-portable method outputs of five or six gallons per minute are the most that can be handled without excessive fatigue on the one hand or waste of wash on the other. Under any of the stationary or semi-portable methods the maximum output that can be handled by any one spray man is governed by the rapidity with which he can drag his pipe line and move from tree to tree. This is a point of considerable practical importance, particularly when considering the possibility of speeding up spray procedure.

In the present connection, it now remains to outline the effect of spraying method upon the amount of time expended on general preparation, laying out and taking up the pipe system, filling up, etc. Unfortunately, for most of the period covered by this report all these operations have been grouped together under the one heading " general preparation moving pipes, etc." A detailed analysis of this labour would have been most helpful, but in any case it is clear that by far the largest amount of the total spraying time is spent on this part of the work. Of the total man hours spent in spraying plots 7B and 8A that spent in general preparation filling up, etc., is never less than half, and has been as much as two-thirds. Few growers realize how much time and money are expended upon this " unproductive " work, and there cannot be any doubt that its reduction is most desirable in the interests of both economy and speed of application.

Mobile spraying as at present organised and carried out at Long Ashton, still shows a high proportion of the total time spent in general preparation, filling up, etc. In 1935, for example, out of a total of 7½ man hours spent spraying plot 8A six were spent in preparation, filling up and cleaning the machine. This is admittedly a very high proportion, but it is pointed out that the experimental nature of the work often involves the use of two or more different washes on this plot and that the machine must be cleaned out between each wash. In fact spraying at Long Ashton is rarely if ever the straightforward job that it is on a large farm where a uniform wash is employed throughout. In this connection it may be pointed out that the time spent filling up, etc., would be materially reduced relative to the " nozzle hours " by arranging for more " local " supplies of wash. This would be comparatively easy if a uniform treatment was being carried out, but it has been found that owing to the frequent changes in wash it is often better to return to the filling station. In discussing the present data these points must be kept clearly in mind since no allowance has been made for the delays encountered by the frequent changes in wash and the many return visits to the filling station.

c. Effect of Spraying Method upon Horse and Tractor Requirements.

An examination of Tables I and III shows that with the introduction of mobile spraying in 1933 the employment of horse labour was eliminated, but the employment of a tractor increased considerably. Under the semi-portable method in use prior to 1933 horses were employed in hauling wash on to the plot and in carting the pipe system from one plot to another. In 1928 when steel mains were used the horse labour expended on plots 8A and 7B was 24 and 22 hours respectively, but in subsequent years when long lengths of rubber pipe were used the horse labour fell to about half this amount. The cost of horse labour at 2/- per hour, including the horseman, never fell below £1 for plot 8A, or 13/- for plot 7B when spraying by the semi-portable method. Both these plots were sprayed in 1932-33 by the " semi-mobile " method which, owing to the design of the machine in use, still required the use of horse labour. This, however, was reduced to 13/- on plot 8A and 9/- on plot 7B.

With the introduction of the large mobile machine of large tank capacity horses were no longer required, but a tractor was in constant use during the time spraying was in progress. It will be noted, therefore, that in the data relating to mobile spraying the total tractor hours item is a rough guide to the total time spent spraying. In this connection it should be noted that owing to the increased speed of spraying under the mobile system the cost of tractor hire under this system scarcely exceeds that of horse hire under the semi-portable method. On plot 8A the cost of tractor hire for mobile spraying has in fact never exceeded that of horse hire for semi-portable spraying, notwithstanding that the former is charged at 4/- per hour whereas horse labour is charged at 2/-.

It appears, therefore, that mobile spraying does not necessarily mean increased expenditure on haulage costs. On most modern fruit farms a tractor is a part of the general equipment and a change to mobile spraying does not therefore necessarily involve additional expenditure on the provision of haulage facilities.

d. Effect of Spraying Method upon the Amounts of Wash Used.

The amount of wash used per acre per spray application depends upon a number of factors, the more important of these being wind velocity, whether a " drenching wash " or a " fine mist cover " is aimed at, the desired degree of speed, and finally the experimental or commercial needs of the spray. At Long Ashton two factors are particularly dominant, wind velocity and the experimental work in progress. For various reasons a drenching wash is frequently desired and wind velocities of 12—16 miles per hour are commonly blowing at spraying time. A calm spraying day for Long Ashton is one on which the wind falls to 8 miles per hour. For these reasons a complete discussion of this aspect of the problem is not attempted, but attention may be called to one particular aspect of the problem. On plots 8A and 7B, the introduction of mobile spraying in 1933 was accompanied by an increase in the amounts of wash used. In 1935, however, there was a reduction on plot 8A to about half that of the two former years, and on plot 7B a reduction of 120 gallons on the amount used in 1934. This reduction is attributable almost entirely to a conscious effort to reduce the amounts of wash to a minimum. With the introduction of mobile spraying it was felt that, owing to the speed of travel, safety and adequate control necessitated, the use of larger amounts of wash than had been employed under the semi-portable system was required. It appears, however, that these ideas were without foundation and that the mobile method does not necessarily mean an increased use of wash as compared with the semi-portable method, although when first used there will almost certainly be a tendency to use more wash. It is significant to note that plot 8A was sprayed in 1935 with only 480 gallons, or 240 gallons per acre, and that the control was perfect. Although the data are not included, the consumption of wash on this plot in 1936 was only 500 gallons and the control was again perfect. While the data presented are inadequate basis for sweeping generalisations, it is clear that, with experience, mobile spraying does not mean an increased use of wash, but that it may in fact effect an economy of spray fluid.

e. Effect of Spraying Method upon the Cost of Applying the Wash.

Attention may now be called to the cost of making the spray application, as distinct from the total cost of spraying.

The reduction in labour costs that has been achieved during the seven year period 1928-35 is outstanding. For the two acre plot 8A the expenditure on labour fell from £1 8s. 6d. in 1928 to 5/8 in 1935. The important point to notice is the marked fall in labour costs that accompanied the introduction of mobile spraying 1933-34. A labour cost of 2/10 per acre for spraying excluding the tractor driver must be regarded as economical on any method, particularly when it is remembered that this figure includes the cost of preparation, cleaning of the machine and the haulage of wash, and that spraying is proceeding at the rate of an acre in $1\frac{1}{2}$ hours with a total spraying crew of three. Under the "semi-portable" method the high cost of labour is largely accounted for by the time taken to move the pipe system and by the lower output per man. Even under the mobile method the 2/10 per acre is very largely expended upon the work of filling up, mixing the wash and preparing the machinery for work, and a further reduction is possible by improvements in water supply and management.

Horse labour for the two acre plot 8A only occurs during the period 1929 to 1933 when spraying was by the semi-portable method. During this period the cost of horse labour for these two acres varied between £2 8s. and £1 with an average of £1 10s., or 15/- per acre. Under the mobile system horse labour was completely eliminated, its place being taken by the tractor which was used both for hauling the wash on to the plot and for hauling the spraying machine through the plantations. The cost of using the tractor as above varied between £1 and 12/- or between 10/- and 6/- per acre. It should be noted, therefore, that notwithstanding the fact that a tractor with man is charged at more than double the rate of a horse and man, the cost of using a tractor for all the haulage work in connection with mobile spraying is less than that of using horses for the one purpose of carting water to the semi-portable unit.

The combined cost of labour, horses and/or tractor gives the total cost of making the spray application. Reference to Table I shows that with the introduction of mobile spraying there is a marked fall in the above total cost. Prior to 1934, *i.e.* during the period of semi-portable spraying, £2 1s. 6d. was the lowest figure recorded for these combined items of expenditure, whilst it has been as high as £3 17s. 6d. In 1934 and 1935 under the mobile system these combined costs fell to £1 9s. 9d. and £1 4s. 3d. respectively, and for 1936 reached the remarkably low figure of 17/8. Clearly, therefore, in so far as the cost of making a spray application on mature bush apples on this plot is concerned, the mobile method shows a saving of at least 25% as compared with the semi-portable method in use prior to 1933-34.

II. The Cost of Spraying Soft Fruit Bushes.

Attention may now be directed to the cost of making a spray application to soft fruit bushes, in this case black currants. Two plots are available for study, one being one acre and the other about $\frac{3}{4}$ acre in extent. The bushes on both plots were planted at 6 × 5 feet in the year 1927-28. Owing to the above planting distance mobile spraying is impossible, the bushes being sprayed by running out long lengths of rubber pipe. The changes of spraying on this plot therefore refer to developments in the type and capacity of the spraying machines used and to improvements in technique and management.

Reference to Tables IV and V show that spraying with knapsacks was comparatively expensive. In fact on plot 4A the cost in labour was £1 2s. 6d. and was the highest recorded figure for this plot, in spite of the fact that the bushes were only one year old and only 86 gallons of wash were used.

Further reference to the above tables shows that the introduction of a large machine in 1933-34 was accompanied by a marked reduction in the time taken to spray these plots. On plot 4A, for example, the nozzle hours were reduced from five to three. On plot 17B there is not such a marked reduction, but in this case there has been a small additional planting of bushes which has increased the spraying to be done. The above reduction in spraying time is not due to a lessened quantity of wash used.

It will be noticed that with the introduction of a large machine in 1933-34 there is a marked fall in the cost of making the spray application on plot 4A but not on plot 17A. This difference is due almost entirely to the cost of hauling wash on to these two plots. Tractor costs have risen over the last three years from 6/- to 10/- on plot 17A, whereas they have only risen from 2/- to 3/- on plot 4A. Furthermore labour costs have fallen from 7/6 to 5/5 on plot 4A but have risen from 2/3 to 3/4 on plot 17B.

This differential effect is important since it brings into prominence the importance of water supplies. On plot 4A, the water supply occurs on the plot so that water haulage is eliminated and full advantage may be taken of the output and pressure available. On plot 17A, the wash and machine must be hauled on to the plot, and after completion of the work the machine must be taken away again. These movements largely offset any advantage gained by a larger output. On large plots there would no doubt be an advantage from the use of a large machine, but on these small plots the time spent getting to and from the job is very large in proportion to the time actually employed in spraying.

This point may be further emphasised by reference to the data for plot 2, Table II. The material on this plot comprises plums interplanted with half standard plums. Spraying on this plot has been by the semi-portable method throughout the period, and a marked economy has accompanied the introduction of a large machine in 1933. There again water supplies occur by the side of the plot and no time is spent on this part of the work.

III. The Cost of Spraying Plum Trees.

The complete data are set out in Table VI, where the following features are particularly noticeable.

The first is the very high cost of spraying by knapsacks. In the year following planting it required a total of 39 nozzle hours and 60 man hours at a cost of £6 15s. to apply only 204 gallons of wash. In the following year the same plot was sprayed by the $3\frac{1}{2}$ H.P. machine in 15 nozzle hours and 25 man hours at a cost of only £1 8s. 9d., using 300 gallons of wash. Spraying even young trees by knapsacks is clearly uneconomic.

The second point of interest is the rapid rise in the quantity of wash required to spray this plot. This rise may be used as an indication to the development in tree size. The years 1933 and 1934 show rises of about 400 gallons, and 1935 a further rise of 200 gallons for the plot. In the latter year a total of 1,600 gallons of wash was used on this plot or about 355 gallons per acre.

The third point is the marked reduction that has occurred in the nozzle hours expended spraying this plot over the period 1929-35, notwithstanding the above increases in total quantity of wash used. Thus in 1929-30, *i.e.* the year following planting, a total of 15 nozzle hours was expended in applying 300 gallons of wash, whereas in 1935-36 when the trees were three parts grown the work was done in $4\frac{3}{4}$ nozzle hours, using 1,560 gallons of wash. Owing to the continually increasing size of the trees on this plot and the increasing amount of work involved in spraying, the introduction of mobile spraying is not marked by a reduction in costs of application as it was in the case of mature trees on plot 8A. It is shown, however, that under the mobile system the work is speeded up and cost of application kept at about the same level as for the stationary method, although almost twice the amount of wash has been used. In considering the spraying of this plot, it should be remembered that the wash must be hauled a distance of about 800 yards and that the expenditure includes haulage costs. Since this latter expenditure has been doubled owing to the greatly increased quantity of wash used, the maintenance of costs at about the same figure over the four years 1932-35 is an indication of the marked economies that have been effected in other directions, notably in time taken to apply the wash.

IV. The Cost of Spraying Young Orchard Trees.

The only other plots of importance from the present point of view are plots 21 and 22. These comprise young standard apple trees planted in the winter of 1928-29. The trees of plot 21 are in clean cultivation with an interplant of black currants in one direction, and those of plot 22 are in grass sod.

Considering first the young trees in grass, it is shown that the introduction of mobile spraying has reduced both the total labour requirement and the total time required for spraying. Under the mobile spraying method the nozzle hours expended on this plot are only $1\frac{3}{4}$, and the total time for the completion of the spraying of this five acre block is a little under two hours. As regards cost, under the semi-portable method the cost of making the spray application was never less than 15/6, whereas under the mobile system it was never more than 9/5.

Owing to the interplant of black currants on plot 21, it is impossible to give a separate figure for the cost of spraying the trees or the black currant bushes. Reference to Table VII shows that as in the case of plot 18 there has been a rapid growth in the size of the trees and black currant bushes, necessitating the use of an increased amount of wash. The data indicate that with the introduction of mobile spraying in 1933-34 there was a reduction in the nozzle hours expended on spraying this plot, notwithstanding the fact that a larger amount of wash was used owing to increase in tree size. In spite of the larger size of the trees and the corresponding increased use of wash, the labour hours, and in consequence the cost of labour for spraying, has remained about the same over the period 1931 to 1935, the cost of labour varying between 13/3 and 10/6.

DISCUSSION.

This discussion is confined to the effect of method upon the cost of spray applications and is not concerned with the total cost of spraying since this involves considerations of amounts and composition of the washes used, points which are not at present under review. The discussion is also concerned largely with winter washing because it is the most simple of the several spray applications.

In the first place, it is emphasised that the costs submitted have been obtained as the result of detailed records taken when spraying was in progress, and are the actual costs for the specified plots. No deductions have been made for minor breakdowns or stoppages. The costs include the haulage of wash, mixing, preparing and cleaning the machine, and the use of horses and tractors, all of which have been charged for at first-class rates so that in commercial practice the costs could be reduced by anything up to 10% or 15%.

Effect of Spraying Method upon Labour Requirements.

From the farm management point of view, expenditure on labour for spraying is often not so important as the difficulty of obtaining the necessary labour and of maintaining the general routine farming operations during the spraying periods. It has already been mentioned that at Long Ashton the semi-portable method of spraying in use before 1933 required the services of six men and a horse. This relatively large unit was only handling a maximum output of 7—8 gallons per minute when working, *i.e.* one gallon per minute per man, or allowing for the time spent in moving the system, a total output of about 4 gallons per minute throughout a working day. It was found impossible to reduce the number of men employed on this unit without seriously reducing its efficiency. In this connection, it may be mentioned that quite recently the writer saw spraying in progress on a large farm where a total of eight men was employed on a large 1935 machine with an output of 18—20 gallons per minute. On test it was found that this large gang was using only 14—16 gallons per minute or about 2 gallons per minute per man. It would seem, therefore, that while the rate of application may have been speeded up as the result of introducing large capacity machines, the semi-portable method still requires the use of a relatively large group of men. Under the mobile system it has been shown that not only is the expenditure on labour reduced as compared with the semi-portable method, but what is even more important the number of men employed is reduced to a maximum of three, including the tractor driver. In order to bring out this point more clearly Table IX has been prepared for the labour hours expended on spraying each of three different plots. Plots 8A and 7B are mature bush apples, at 15 × 15 feet, and plot 22 comprises young standard apple trees planted in grass on a 36 feet triangular plant. Details of these plots have been given earlier. The trend of these figures is unmistakable and suggests that under modern conditions, when the number of men available is often limited, a change from the semi-portable to mobile spraying offers a partial solution of this problem.

TABLE IX.

SHOWING THE TOTAL LABOUR HOURS EXPENDED UPON SPRAYING EACH OF THREE SEPARATE PLOTS.

Year.	*Method of Spraying.*	*Plot Number.* 8A	7B	22
1928–29	Knapsacks	33	23	—
30	Semi-portable	18	15	11
31	,, ...	25	16	10
32	,, ...	16	—	—
33	,, ...	20	13	7
34	Mobile	13	9	4
35	,, ...	11	8	4
36	,, ...	11	6¼	3¼

Effect of Spraying Method upon the Speed of Application.

While an efficient control is undoubtedly the first and most important requirement of any spraying treatments speed of application is undoubtedly the second consideration. Summer washes must often be applied within very narrow time limits, and in such circumstances economy is secondary to speed.

The data presented in this paper show that over the seven year period 1929-36 the area sprayed per unit of time has been materially increased. This is due mainly to the adoption of the mobile method, but the introduction of larger and more efficient spraying machinery has also been of importance. For example the total time taken to spray the two-acre plot 8A by the mobile method in 1935-36 was 3 hours, the work being carried through by a spray crew of three men, including the tractor driver. The above time includes the preparation of the wash and its transport on to the plot in question. In 1930-31 it took six men over five hours to do the same piece of work. Moreover, these men required the use of a horse and cart throughout the entire period. The above two-acre plot has now been sprayed on at least five occasions in a total of three hours, and once in 2½ hours, using not less than 350 gallons per acre, indicating that under the present organisation the mobile spraying crew can spray at the rate of an acre of mature bush apple trees in 1½ hours, this including complete service. If a light spraying such as 250 gallons per acre were used the speed could be increased.

The rate of spraying on young trees has been speeded up even more by the mobile as compared with the semi-portable method.

Thus in 1930-31 it took six men and a horse about 12 hours to spray plot 21 (5½ acres), whereas in 1935 it was sprayed in 6¼ hours by three men using the mobile method. It is evident that fewer men can spray the same plot in less time by the mobile than by the method of laying out a temporary pipe system.

It has been shown that the use of a large, efficient machine may reduce the time taken to spray a given plot by the semi-portable method. This speeding up is most noticeable on those plots where the water is immediately available. When water must be hauled on to the plot the effect of a large output is minimised owing to the time spent getting up supplies. This suggests that careful consideration should be given to the provision of adequate facilities for reducing the time spent filling up and getting up supplies. This applies equally to both the mobile and semi-portable methods.

The economies that have been effected in the semi-portable method have been obtained through the employment of increased outputs per man per minute. It is obviously impossible at this stage to discuss every aspect of the spraying problem, but generally increased speed of spraying is most economically obtained by increasing the output per man per minute. The present trend both at Long Ashton and on commercial fruit holdings is towards a still further increased output. At Long Ashton, outputs of 6—8 gallons per man per minute have been maintained for the last three years under the mobile system, this representing a total output of 12—16 gallons per minute by the spray men. On certain plots of large standard trees the total output of the machine, viz. 20 gallons per minute, has been used by these two men. Given a larger output it could have been handled by these men and the rate of spraying thereby increased.

These working conditions have necessitated a careful consideration of the physical effort required to carry out the work, and provision has been made to lighten the work as much as possible. Triple-nozzle adjustable spray guns have contributed largely to this end. It has also been found that the use of disc apertures of 9/64 to 11/64 inch with the gun set at a medium adjustment gives a large output of good quality, the drops, although small, travelling at very high velocity and therefore reaching the tops of the trees and penetrating every part of the tree. From practical trials and experience it has been found that under any "stationary" method whereby the sprayman has to pull his pipe system, an output of 5—6 gallons per minute is the maximum a man can reasonably handle. If the output is raised beyond this amount the man either wastes the wash because he cannot move quickly enough, or else if he does move quickly fatigue soon sets in and his efficiency is reduced. Under the mobile system, outputs up to 14 gallons per minute per man can be handled without any more fatigue than outputs of half this amount since the man is relieved of all physical effort except that of directing the wash on to the trees.

The importance of machinery and accessories in the above speeding up of the spraying operations cannot be over emphasised. In order to take full advantage of the mobile method adequate capital in the form of suitable machinery must be available. For very rapid work high output nozzles or spray guns must also be available. Thus in 1936 the spraying machinery and its accessories had an initial capital value of £260, whereas the semi-portable machine had a capital value when new of only £120. Notwithstanding this difference, it must be insisted that economies have been shown by the use of the larger machine after charging for its use and its depreciation.

Mobile spraying also depends to a large extent upon adequate traction facilities since a large machine with a tank capacity of 3—400 gallons necessitates the use of a good tractor. Where such machines are in use adequate traction facilities are also available as part of the general farm equipment. In this connection the importance of adequate tank capacity and low weight, high-capacity pumps may be especially emphasised. Large, heavy, slow-running pumps operated by large gears and heavy eccentrics, are not primarily suited for installation in plants intended for use on the mobile system, and in this connection attention should be given to the merits of newer types of short stroke fast-running pumps. These are now being constructed both in this country and in U.S.A., and when properly designed offer a pump unit eminently suited for use in machines intended for use as mobile units. Intending purchasers of new spraying machines are urged to consider very carefully the present-day trends in the development of spraying machinery and even more particularly the developments in spraying technique. The trend is certainly towards the installation of central pumping plants and mobile spraying. Working pressures are becoming stabilized at about 5—600 lbs. per square inch, and outputs of 18—20 gallons per minute at these pressures are becoming a minimum standard for all except very small holdings. The adaptability of spraying machinery for use either as a "stationary" or a "mobile" unit should be considered, since on most fruit farms the presence of fruit trees of many varieties, ages and planting distances, soft fruits and perhaps vegetables, necessitate the use of a machine that will be economical and speedy in use.

While speed is not so very important in the application of a winter wash it is of paramount importance in the application of all summer washes, more especially those intended for the control of apple scab and apple sawfly.

The data so far presented have been obtained during the application of winter washes where conditions are admittedly difficult and speed not so important. For comparison, therefore, the details of a summer spray application made on the 28th May, 1936, may be cited. This was a routine lime sulphur-nicotine wash intended for the control of apple sawfly and was made in the presence of a group of Kent Fruit Growers who were visiting Long Ashton. Plot 8A, which it will be remembered, is a two-acre block of mature bush apple trees planted at 15 × 15 feet, was sprayed by the mobile method. The spray crew consisted of three men, including the tractor driver. Wash was hauled a distance of about 300 yards by taking the spraying machine back to the central filling station. The machine was an 8 H.P. 20 G.P.M. outfit, working at 400 lbs. pressure per square inch and using spray guns, each man with an output of 6 gallons per minute or a total output of 12 gallons per minute. The total application was 800 gallons or 400 gallons per acre. There was a cross wind blowing at about 8—10 miles per hour. The time and cost details are as follows :—

Total time start to finish. 3 hours—including all preparations, mixing wash, haulage and a stoppage of 15 minutes owing to a blocked petrol pipe.
Time spent filling up and fetching wash. 1 hour 50 minutes.
Time spent applying the wash. 1 hour 10 minutes.

Costs.	£	s.	d.
Hire of Tractor and Driver, say 5/- per hour	0	15	0
Hire of Spraying Machine, say 2/6 per hour	0	7	6
Labour, 2 men for 3 hours, at 10d. per hour	0	5	0
Spray Fluid, 8 galls. Lime Sulphur at 1/4 per gallon	0	10	8
4 lbs. Nicotine at 10/- per pound	2	0	0
4 lbs. Wetter at 3/- per pound	0	12	0
Management costs, say	0	5	0
Total Cost	£4	15	2

Total cost, say £5 0 0.
Total cost per acre, £2 10 0.
Total cost per tree, 3½d.

It is pointed out that the above costs have been calculated on a generous scale. Purchases in bulk would reduce the price of all commodities. Management at 2/6 per acre per spray application is generous and the amounts of spray used liberal in view of the serious nature of the pest under consideration and the wind. Under commercial conditions the inclusive cost would not exceed £2 per acre, and the rate of spraying would proceed at about one acre per hour.

Effect of Spraying Method upon Cost.

Mobile spraying has resulted in a substantial saving in cost in all cases where it has been used. In order to bring out this point more clearly the data for certain plots have been collected into Table X.

TABLE X.

Showing the Cost of Spray Application on Certain Plots.

Year.	*Method of Application.*	*Plot* 8A.	*Plot* 7B.	*Plot* 22.
		£ s. d.	£ s. d.	s. d.
1928–29	Semi-portable	3 17 6	3 1 3	—
30	,,	2 1 6	1 9 3	16 3
31	,,	2 1 9	1 6 0	15 6
32	,,	2 0 0	—	—
33	,,	2 14 0	1 12 9	15 9
34	Mobile	1 9 9	18 9	9 0
35	,,	1 4 3	1 0 0	9 0
36	,,	17 8	16 8	9 5

In comparing these costs with those of other investigations the basis of estimation must be kept constantly in mind and allowances made for the differences in amounts of wash used and other factors such as the charges for hire of machinery, foreman's time, etc. For instance, the cost of the wash is always a large part of the total cost and at Long Ashton heavy applications of wash are usually for reasons already mentioned. From 1929 to 1935 inclusive, heavy applications of wash were made, but in 1936 a much lighter application was used. It is impossible at this stage to discuss the technical reasons for the reduction in the quantities of wash used per acre, but it may be stated that these smaller quantities of wash used have given an adequate control and may be regarded as the quantities that would be used under normal commercial conditions. By costing the spraying on the basis of the lower quantities of wash used, the costs per acre or per tree will be reduced accordingly.

A review of the data as a whole indicates that the successful organisation of a spraying team involves a consideration of several factors, the more important of these being the available labour both as regards quantity and quality, the capacity and design of the spraying machinery and finally the available sources of water. It has been found during these investigations that in the case of the semi-portable method the main problem is that of reducing the time taken to move the pipe system. In mobile spraying it is the problem of reducing the time taken to fill up the machine. Recent developments and improvements in spray guns enable the spray men to handle very large outputs, but the question of fatigue must be kept clearly in mind. In this connection, mobile spraying has a very great advantage since it reduces physical effort to a minimum. The time spent filling up still occupies too much of the total time and the solution lies in larger tank capacities and the establishment of more " local " supplies of wash.

It must not be concluded that mobile spraying is the only possible method to adopt and that economical results cannot be obtained by any other system. It is hoped, however, that the publication of these figures will draw attention to the relative distribution of spraying costs as between labour, horse and tractor hire, use of spraying machinery and overhead expenses generally. Furthermore, it is suggested that growers should attempt to keep a simple form of records, not necessarily over the whole farm but on one or two typical blocks of fruit trees. In this way the importance of organisation will be more fully realized and the information provided will serve as a basis for developing a better and more economical technique.

In comparing the above data with that obtained on commercial fruit holdings, it must be remembered that at a Research Station several different washes may be applied to the one plot, necessitating separate mixings and sometimes the washing out of the tank, etc. The above costings include all such labour. Moreover, for experimental reasons, each plot is sprayed separately, whereas much valuable time might be saved by taking the work in a straightforward manner.

It is hoped in a future communication to abstract certain of the costs set out in this paper and compare them with the published results of other workers in this interesting field of practical fruit culture.

SUMMARY AND CONCLUSIONS.

A study of spraying methods and costs has been made on certain plots at Long Ashton over the seven year period 1928-35.

The semi-portable method, consisting of laying out a temporary pipe system and pumping from selected stations, was found to require at least six workers. The rate of spraying was slow, owing mainly to the large amount of time occupied in moving the pipe system.

The introduction of a larger and more powerful spraying machine increased the rate of spraying by the above method, but required the same number of workers, and except where water supplies were located on the plot showed only slight economy of working.

The introduction of mobile spraying enabled the spraying unit to be reduced to a maximum of three men and halved the time required to spray any given plot. This reduction in both the number of workers and spraying time has resulted in a marked monetary economy, in some cases the cost of applying the wash being almost halved.

The mobile method relies for its efficiency and speed upon a suitably designed machine. Tank capacity, weight, size, filling arrangements, etc., all become very important considerations. By using suitably designed spray guns, each sprayer can " place " outputs up to 10—14 gallons per minute by this method. On mature plantations of bush apples or pears outputs of 6—8 gallons per minute per man have been maintained at Long Ashton since 1933. On large standard trees in grass orchards much larger outputs are attained. By this method a uniform rate of spraying can be maintained in mature orchards irrespective of variations in tree size, but in young plantations the output may be reduced to 2 or 3 gallons per minute, and the rate of spraying slightly increased.

The organisation of mobile spraying at Long Ashton is capable of much further improvement when adopted for use on commercial fruit holdings. Under these latter conditions arrangements can be made to reduce filling and preparation time. At Long Ashton the experimental nature of the work frequently causes considerable delays. These delays have been included in the data presented in the foregoing pages and must be allowed for when considering them.

Growers are urged to keep careful records of some of their spraying operations since a careful analysis of such records will enable them to make improvements in their organisation and effect economies in operation.

Rapid developments in spraying technique are now being made, and before purchasing new machinery growers are urged to study the trend of these developments so that suitable machinery may be installed and an economical method developed.

REFERENCE.

(1) Maynard, J. G. The Economics of Spraying Fruit Trees. *Ann. Report, Long Ashton Res. Stn*, p. 168, 1929.

TABLE I.

Plot 8A.

Area : 2 Acres.

Date.	*Machine and Method used.*	*Total number of men em-ployed.*	*Number of guns em-ployed.*	*Prepar-ation, filling and mixing and clearing and moving pipe system.*	*Total labour hours.*	*Total nozzle hours.*	*Total horse and horse-man hours*	*Total Tractor and Tractor man hours.*	*Total gallons of wash used.*	*Total cost of labour*	*Total cost of horse and horseman.*	*Total cost of Tractor and driver.*	*Total cost of application.*
										£ s. d.	£ s. d.	£ s. d.	£ s. d.
1928 29	3½ H.P. Semi-portable ,, steel mains ..	7	4	24	38	14	24	¼	750	1 8 6	2 8 0	1 0	3 17 6
29–30	,, Long lengths rubber pipe ..	7	4	8½	18	9½	13½	¼	575	13 6	1 7 0	1 0	2 1 6
30–31	,, ,, ..	7	4	14½	25	11½	11	¼	775	18 9	1 2 0	1 0	2 1 9
31–32	,, ,, ..	7	4	7⅓	16	8⅔	10	2	590	12 0	1 0 0	18 0	2 0 0
32–33	,, semi-mobile ..	5	2	12	20	8	6½	6½	700	15 0	13 0	1 6 0	2 14 0
33–34	8 H.P. Mobile ..	3	2	9⅓	13	3⅔	—	5	960	9 9	—	1 0 0	1 9 9
34–35	,, ,, ..	3	2	6¾	11	4¼	—	4	1000	8 3	—	16 0	1 4 3
35–36	,, ,, ..	3	2	6	7½	1⅓	—	3	480	5 8	—	12 0	17 8

TABLE II.

Plot 2.

Area : 1 Acre.

										£ s. d.	£ s. d.	£ s. d.	£ s. d.
1928–29	3½ H.P. Semi-portable steel mains ..	4	2	15	29	14	7	—	950	1 1 9	14 0	—	1 15 9
29–30	,, Long lengths rubber pipe ..	5	3	8	20	12	6	¼	625	15 0	12 0	1 0	1 8 0
30–31	,, ,, ..	6	4	7⅓	20	11⅔	7	¼	750	15 0	14 0	1 0	1 10 0
31–32	,, ,, ..	7	4	7½	14	6½	2½	¾	400	10 6	5 0	3 0	18 6
32 33	,, ,, ..	7	4	9¾	16	6¼	3¾	¾	600	12 0	7 6	3 0	1 2 6
33–34	8 H.P. ,, ..	5	4	10	13	3	—	½	760	9 9	—	2 0	11 0
34–35	,, ,, ..	6	4	8¾	12	3¼	—	1	780	9 0	—	4 0	13 0
35–36	,, ,, ..	3	2	7½	8¾	1⅓	—	1¼	520	6 2	—	5 0	11 2

TABLE III.

PLOT 7B. AREA : 1½ ACRES.

Date.	Machine and Method used.	Total number of men employed.	Number of guns employed.	Preparation, filling and mixing and clearing and moving pipe system.	Total labour hours.	Total nozzle hours.	Total horse and horseman hours.	Total Tractor and Tractor man hours.	Total gallons of wash used.	Total cost of labour	Total cost of horse and horseman.	Total cost of Tractor and driver.	Total cost of application.
										£ s. d.	£ s. d.	£ s. d.	£ s. d.
1928–29	3½ H.P. Semi-portable steel mains ..	7	4	10	23	13	22	—	700	17 3	2 4 0	—	3 1 3
29–30	,, Long lengths rubber pipe ..	7	4	7	15	8	9	¼	630	11 3	18 0	1 0	1 9 3
30–31	,, ,, ..	5	4	8	16	8	6½	¼	650	12 0	13 0	1 0	1 6 0
31–32	No spray applied ..	—	—	—	—	—	—	—	—	—	—	—	—
32–33	3½ H.P. Semi-mobile ..	5	2	7	13	6	4¼	3¼	560	9 9	9 0	14 0	1 12 9
33–34	8 H.P. Mobile ..	3	2	6	9	3⅙	—	3	960	6 9	—	12 0	18 9
34–35	,, ,, ..	3	2	5	8	3	—	3½	840	6 0	—	14 0	1 0 0
35–36	,, ,, ..	3	2	3¾	6¼	2½	—	3	720	4 8	—	12 0	16 8

TABLE IV.

PLOT 17A. AREA : ¾ ACRES.

										£ s. d.	£ s. d.	£ s. d.	£ s. d.
1928–29	Knapsacks	2	2	3¾	10	6¼	—	—	36	7 6	—	—	7 6
29–30	3½ H.P. Long lengths rubber pipe ..	6	4	1¾	3	1¼	1	¼	150	2 3	2 0	1 0	5 3
30–31	,, ,, ..	6	4	2	4	2	1	¼	150	3 0	2 0	1 0	6 0
31–32	,, ,, ..	5	3	2	4	2	1	¼	150	3 0	2 0	1 0	6 0
32–33	,, ,, ..	4	2	2½	6	3½	3	—	140	4 6	6 0	—	10 6
33–34	8 H.P. ,, ..	3	2	1⅔	3	1⅓	—	1½	150	2 3	—	6 0	8 3
34–35	,, ,, ..	3	2	1⅔	3	1⅓	—	2	240	2 3	—	8 0	10 3
35–36	,, ,, ..	4	2	3	4½	1½	—	2½	220	3 4	—	10 0	13 4

TABLE V.

PLOT 4A. AREA : 1 ACRE.

Date.	Machine and Method used.	Total number of men employed.	Number of guns employed.	Preparation, filling and mixing and clearing and moving pipe system.	Total labour hours.	Total nozzle hours.	Total horse and horseman hours.	Total Tractor and Tractor man hours.	Total gallons of wash used.	Total cost of labour	Total cost of horse and horseman.	Total cost of Tractor and driver.	Total cost of application.
										£ s. d.	£ s. d.	£ s. d.	£ s. d.
1928–29	Knapsacks	2	2	12¾	30	17¼	—	—	86	1 2 6	—	—	1 2 6
29 30	3½ H.P. Long lengths rubber pipe ..	4	2	5	9	4	2	¼	180	6 8	4 0	1 0	11 8
30–31	,, ,, ..	6	4	7¾	12	4½	5	¼	400	9 0	10 0	1 0	1 0 0
31–32	No spray applied ..	—	—	—	—	—	—	—	—	—	—	—	—
32–33	3½ H.P. Long lengths rubber pipe ..	6	4	6	11	5	4	½	350	8 3	8 0	2 0	18 3
33–34	8 H.P. ,, ..	5	4	7	10	3	—	½	450	7 6	—	2 0	9 6
34–35	,, ,, ..	5	4	5¼	8	2¾	—	½	480	6 0	—	2 0	8 0
35–36	,, ,, ..	5	4	4¾	7¼	2½	¼	¾	480	5 5	6	3 0	8 11

TABLE VI.

PLOT 18. AREA : 4½ ACRES.

Date.	Machine and Method used.	Total number of men employed.	Number of guns employed.	Preparation, filling and mixing and clearing and moving pipe system.	Total labour hours.	Total nozzle hours.	Total horse and horseman hours.	Total Tractor and Tractor man hours.	Total gallons of wash used.	Total cost of labour	Total cost of horse and horseman.	Total cost of Tractor and driver.	Total cost of application.
										£ s. d.	£ s. d.	£ s. d.	£ s. d.
1928–29	Knapsacks	2	2	21	60	39	–	–	204	6 15 0	—	—	6 15 0
29–30	3½ H.P. Long lengths rubber pipe ..	6	4	10	25	15	4½	¼	300	18 9	9 0	1 0	1 8 9
30–31	,, ,, ..	6	4	17	29	12	11	½	550	1 1 9	1 2 0	2 0	2 5 9
31–32	,, ,, ..	8	4	11⅓	19	7⅔	6	1½	460	14 3	12 0	6 0	1 12 3
32–33	,, ,, ..	5	2	9	16	7	6	6	840	12 0	12 0	1 4 0	2 8 0
33–34	8 H.P. Mobile ..	3	2	13⅙	16	5⅚	—	6	1210	12 0	—	1 0 0	1 12 0
34–35	,, ,, ..	3	2	15⅔	22	6⅓	—	8	1600	16 6	—	1 12 0	2 8 6
35–36	,, ,, ..	3	2	15⅓	20	4⅔	—	8	1560	15 0	—	1 12 0	2 7 0

TABLE VII.

PLOT 21.

AREA : 6½ ACRES.

Date.	*Machine and Method used.*	*Total number of men employed.*	*Number of guns employed.*	*Preparation, filling and mixing and clearing and moving pipe system.*	*Total labour hours.*	*Total nozzle hours.*	*Total horse and horseman hours.*	*Total Tractor and Tractor man hours.*	*Total gallons of wash used.*	*Total cost of labour*	*Total cost of horse and horseman.*	*Total cost of Tractor and driver.*	*Total cost of application.*
										£ s. d.	£ s. d.	£ s. d.	£ s. d.
1928–29	Knapsacks	2	2	9½	32	22½	1½	—	126	1 4 0	3 0		1 7 0
29–30	3½ H.P. Long lengths rubber pipe	6	4	12¾	20	7¼	12	½	570	15 0	1 4 0	2 0	2 1 0
30–31	,, ,,	6	4	13½	29	15½	12	½	900	1 1 0	1 4 0	2 0	2 7 9
31–32	,, ,,	5	2	7	15	8	4	1	240	13 3	8 0	4 0	1 5 3
32–33	,, ,,	6	2	8½	16	7½	5¼	5¼	780	12 0	11 0	1 2 0	2 5 0
33–34	8 H.P. Mobile	4	2	9⅔	14	4⅓	—	7	1000	10 6	—	1 8 0	1 18 6
34–35	,, ,,	3	2	10½	16	5½	—	6¼	1280	12 0	—	1 6 0	1 18 0
35–36	,, ,,	3	2	12½	17½	5	—	8	1220	13 1	—	1 12 0	2 5 1

TABLE VIII.

PLOT 22.

AREA : 5 ACRES.

Date.	*Machine and Method used.*	*Total number of men employed.*	*Number of guns employed.*	*Preparation, filling and mixing and clearing and moving pipe system.*	*Total labour hours.*	*Total nozzle hours.*	*Total horse and horseman hours.*	*Total Tractor and Tractor man hours.*	*Total gallons of wash used.*	*Total cost of labour*	*Total cost of horse and horseman.*	*Total cost of Tractor and driver.*	*Total cost of application.*
										£ s. d.	£ s. d.	£ s. d.	£ s. d.
1928–29	Knapsacks	—	—	—	—	—	—	—	—	—	—	—	—
29–30	3½ H.P. Long lengths rubber pipe	4	2	8½	11	2½	6	—	100	8 3	8 0	—	16 3
30–31	,, ,,	4	2	7⅔	10	2⅓	3½	¼	140	7 6	7 0	1 0	15 6
31–32	,, ,,	—	—	—	—	—	—	—	—	—	—	—	—
32–33	,, ,,	6	2	5⅓	7	1⅔	1¾	1¾	140	5 3	3 6	7 0	15 9
33–34	8 H.P. Mobile	3	2	2	4	2	—	1½	160	3 0	—	6 0	9 0
34–35	,, ,,	3	2	2½	4	1½	—	1½	200	3 0	—	6 0	9 0
35–36	,, ,,	3	2	1½	3¼	1¾	—	1¾	200	2 5	—	7 0	9 5

CIDER MAKING TRIALS FOR THE SEASON 1935—36.

By P. T. H. PICKFORD.

Although the 1935 cider apple crop was again heavy in many districts, it was considerably lighter in Gloucestershire, Herefordshire and Monmouthshire than in the previous year.

The average specific gravity of all the juices examined at Long Ashton was 1.0530 as against 1.0544 for 1934.

In spite of the fact that the ciders were not so full in flavour as those of the previous year, they were, on the whole, of good, average quality and very pleasant.

The Cider Competitions.

For the eleventh year in succession these competitions constituted one of the main features of the programme of work in the cider house. They were arranged on similar lines to those described in previous reports, with the following modifications :—

Only one class each was arranged for sharp, sweet and bittersweet varieties. Each of these classes was divided into two groups, A and B, the former for varieties which had previously obtained prizes in the competitions and the latter for varieties which had not previously obtained prizes.

93 entries were received, of which 81 were apples and 12 pears.

The competitions were open to growers residing in the same group of counties as listed for previous years, the entries from the individual counties being as follows :—Devon, 7 ; Gloucester, 8 ; Hereford, 20 ; Monmouth, 2 ; Somerset, 51 ; Worcester, 5.

The ciders were judged on April 22nd, 1936, by Messrs. P. W. D. Izzard, The Pleasaunce, Roydon, Essex ; H. J. Phelps, Tibberton, Gloucester ; R. Whiteway (Whiteways Cyder Co., Ltd.), Whimple, Devon. The perries were judged on the same date by Mr. Stafford Weston (H. Weston & Sons), Much Marcle, Herefordshire. They reported as follows :—

" The judging of the ciders and perries in these competitions took place on April 22nd, 1936.

On the whole, the ciders were of good average quality, and although they were not considered to be as full in flavour as those of last year, in general they were pleasant and they possessed interesting individual characteristics. The perries were not outstanding, but they were considerably higher in quality than the previous year's samples.

Class 1, for Kingston Black ciders, consisted of 11 entries. They were all good ciders and quite typical of the variety. As a class they were very even in quality and proved very difficult to judge.

Class 2A, for Sharp Varieties which had previously obtained prizes in these competitions, comprised 10 entries. In this class a special difficulty was experienced in making the awards, since two very sharp ciders, useful only for blending purposes, and two medium sharp ciders, not requiring blending, stood out well above the remainder. The two former were of the Cap of Liberty variety and the two latter Lambrook Pippin. Owing to the difficulty of comparing such diverse types, it is recommended that first and second prizes should be given in each case. The remainder were only fair in quality.

Class 2B, for Sharp Varieties which had not previously obtained prizes, had only 4 entries. Of these only the first prize cider was above average standard. This cider in fact, compared very favourably with the premier award in the previous class.

Class 3A, for Sweet Varieties which had previously obtained prizes in these competitions, attracted 10 entries. The Sweet Alfords were definitely below their usual high standard of quality, but the remaining varieties were considered to be of average quality.

Class 3B, for Sweet Varieties which had not previously obtained prizes, received 6 entries. With the exception of the 1st prize, this group of ciders was rather poor.

Class 4A, for Bittersweet Varieties which had previously obtained prizes in these competitions, was a very strong class of 26 entries. The quality of these ciders was exceptionally good, although the bittersweet character was very variable throughout. The 1st award in the class was an outstanding cider.

Class 4B, for Bittersweet Varieties which had not previously obtained prizes, contained 14 entries. Most of the ciders in this class, as would be expected, were much below the average quality of those entered in the previous class.

Class 5, for Perries with 12 entries, was somewhat disappointing, no doubt owing to the fact that the outstanding Oldfield variety was represented by one entry only. It was regretted that some of the samples had turned milky, possibly caused through the Pears not being sufficiently ripe when gathered. Perry pears, being of a very perishable nature, we realise it is difficult to get the best results after the transport of the fruit in sacks over considerable distances, and the time taken in transit.

In view of the evenness of the first three Kingston Black ciders, it is recommended that a third prize should be awarded.

In Class 2A, where two high acid ciders and two of the medium acid type stood out in quality, it is recommended that a fourth prize should be given.

Special mention should be made of the inclusion of high and medium-acid types of ciders in one and the same class, which makes comparison in judging very difficult. A similar remark applies to the bittersweet classes where ciders containing widely different amounts of tannin came into the competition.

In conclusion, we have been much impressed by the very satisfactory manner in which all the ciders have been made. Every one shows obvious evidence of most careful treatment: and it is apparent that each fairly represents the vintage quality of the fruit from which it was derived. We are confident that every individual competitor can be assured that his entries have been given the fullest possible opportunity of demonstrating their worth. The competitions have been conducted unquestionably in the most impartial manner and with the utmost degree of care. The staff of the Station concerned can be warmly congratulated on the success of their efforts in this direction."

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (*a*) Time of Filtering. (*b*) Date of Judging. (April 22/36).	Notes on Ciders.
CLASS 1.—KINGSTON BLACK ONLY.				
No. 1. (Keinton Mandeville, Som.)	1.061 (1/11/35)	M. 0.54 T. 0.17 F. 5.7	(*a*) 1.030 (29/11/35) (*b*) 1.029 (22/4/36)	A pleasant cider, but not outstanding in quality.
No. 2. (Hewish, Som.)	1.063 (1/11/35)	M. 0.52 T. 0.20 F. 4.5	(*a*) 1.030 (11/1/36) (*b*) 1.030 (22/4/36)	A very good cider; rich in flavour and particularly pleasant and clean.
No. 3. (Barton St. David, Som.)	1.065 (1/11/35)	M. 0.61 T. 0.19 F. 5.0	(*a*) 1.030 (7/1/36) (*b*) 1.029 (22/4/36)	A rich full-bodied cider, but the acid character was rather too pronounced.
No. 4. (Somerton, Som.)	1.056 (1/11/35)	M. 0.57 T. 0.19 F. 3.7	(*a*) 1.030 (8/1/36) (*b*) 1.028 (22/4/36)	Pleasant and clean, but lacking fullness of flavour.
No. 5. (Charlton Adam, Som.)	1.063 (1/11/35)	M. 0.64 T. 0.20 F. 5.8	(*a*) 1.030 (23/12/35) (*b*) 1.029 (22/4/36)	A very good cider with a soft, pleasant flavour and a very good aroma.
No. 6. (Somerton, Som.)	1.056 (1/11/35)	M. 0.58 T. 0.18 F. 4.3	(*a*) 1.030 (23/12/35) (*b*) 1.030 (22/4/36)	Not outstanding; rather thin in flavour.
No. 7. (Charlton Adam, Som.)	1.055 (1/11/35)	M. 0.66 T. 0.21 F. 4.8	(*a*) 1.030 (7/12/35) (*b*) 1.030 (22/4/36)	Only fair in quality and lacking purity of flavour.
No. 8. (Kingweston, Som.)	1.059 (2/11/35)	M. 0.70 T. 0.22 F. 4.8	(*a*) 1.030 (6/1/36) (*b*) 1.029 (22/4/36)	A good cider, but with too pronounced an acidity for use unblended.

CLASS 1.—KINGSTON BLACK ONLY—*continued*

No. 9. (Kittisford, Som.)	1.064 (2/11/35)	M. 0.68 T. 0.21 F. 4.5	(*a*) 1.030 (31/1/36) (*b*) 1.029 (22/4/36)	Good, full-flavoured, but rather too sharp.
No. 10. (Norton Canon, Hereford)	1.061 (7/11/35)	M. 0.70 T. 0.19 F. 4.1	(*a*) 1.030 (27/1/36) (*b*) 1.028 (22/4/36)	A rather acid, but very good cider.
No. 11. (Bushley, Worcs.)	1.061 (7/11,35)	M. 0.61 T. 0.17 F. 5.7	(*a*) 1.030 (3/2/36) (*b*) 1.030 (22/4/36)	A very fine cider, particularly aromatic but a little too brisk in flavour.

SHARP VARIETIES.—Acidity normally above 0.45 per cent. malic acid.

CLASS 2A.—SHARP VARIETIES which have previously obtained prizes in these competitions.

Cap of Liberty. (Langport, Som.)	1.051 (20/11 35)	M. 0.83 T. 0.22 F. 3.4	(*a*) 1.030 (7/2/36) (*b*) 1.030 (22/4/36)	A very good, clean sharp cider, although not particularly full in flavour.
Cap of Liberty. (Martock, Som.)	1.047 (20/11/35)	M. 0.84 T. 0.23 F. 3.4	(*a*) 1.030 (8/1/36) (*b*) 1.030 (22/4/36)	Very similar to the previous sample.
Fair Maid of Devon. (Newton St. Cyres, Devon)	1.047 (22/10/35)	M. 0.87 T. 0.10 F. 5.6	(*a*) 1.030 (8/11/35) (*b*) 1.029 (22/4/36)	A fair quality cider with a good apple aroma, but rather thin in flavour.
Hartisman. (Easton-in-Gordano, Som.)	1.042 (11/11/35)	M. 0.74 T. 0.16 F. 2.0	(*a*) 1.030 (5/12/35) (*b*) 1.030 (22/4/36)	A good, clean, sharp cider.
Hunt's White Sharp. (Easton-in-Gordano, Som.)	1.040 (29 10/35)	M. 0.54 T. 0.13 F. 3.3	(*a*) 1.030 (28/11/35) (*b*) 1.029 (22/4/36)	A very interesting medium sharp cider.
Improved Kingston Black. (Burghill, Hereford)	1.055 (11/11/35)	M. 0.45 T. 0.18 F. 4.0	(*a*) 1.030 (10/12/35) (*b*) 1.029 (22/4/36)	A good quality cider with a very pleasant aroma, making a palatable drink unblended.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (*a*) Time of Filtering. (*b*) Date of Judging. (April 22/36).	Notes on Ciders.
SHARP VARIETIES—*continued.*				
Lambrook Pippin. (Barton St. David, Som.)	1.053 (2/12/35)	M. 0.48 T. 0.27 F. 3.0	(*a*) 1.030 (31/1/36) (*b*) 1.029 (22/4/36)	A high quality medium-sharp cider ; very good flavour, but the tannin was too pronounced to drink unblended.
Lambrook Pippin. (Kingweston, Som.)	1.057 (2/12/35)	M. 0.61 T. 0.27 F. 5.3	(*a*) 1.030 (28/12/35) (*b*) 1.030 (22/4/36)	Similar to the previous sample, but fuller in flavour.
Langworthy. (Crediton, Devon)	1.045 (8/11/35)	M. 0.41 T. 0.14 F. 3.5	(*a*) 1.030 (10/12/35) (*b*) 1.028 (22/4/36)	Typical of this variety ; a very soft, pleasantly flavoured cider.
Woolston Spice. (North Cadbury, Som.)	1.034 (2/12/35)	M. 0.43 T. 0.11 F. 6.3	(*a*) 1.030 (7/12/35) (*b*) 1.030 (22/4/36)	Thin and watery, lacking in character.
CLASS 2B.—SHARP VARIETIES which have not previously obtained prizes in these competitions.				
Bastard Tom Putt. (Easton-in-Gordano, Som.)	1.050 (22/10/35)	M. 0.73 T. 0.16 F. 4.4	(*a*) 1.030 (22/11/35) (*b*) 1.030 (22/4/36)	A very good, clean, sharp cider with a fine apple aroma.
Cherry Pearmain. (Shucknall Court, Hereford)	1.056 (8/11/35)	M. 0.72 T. 0.22 F. 4.3	(*a*) 1.030 (20/12/35) (*b*) 1.030 (22/4/36)	A good cider, but with rather harsh acidity.
Neverblight. (Shapwick, Som.)	1.056 (29/10/35)	M. 0.67 T. 0.25 F. 6.0	(*a*) 1.030 (22/11/35) (*b*) 1.029 (22/4/36)	A fair quality cider.
Neverblight. (North Cadbury, Som.)	1.046 (21/11/35)	M. 0.41 T. 0.19 F. 7.0	(*a*) 1.030 (12/12/35) (*b*) 1.029 (22/4/36)	Pleasant, but not outstanding.

Sweet Varieties.—Acidity normally below 0.45 per cent. and tannin below 0.20 per cent.

CLASS 3a.—Sweet Varieties which have previously obtained prizes in these competitions.

Jackson's White. (Charlton Mackrell, Som.)	1.047 (18/10/35)	M. 0.24 T. 0.15 F. 7.2	(*a*) 1.025 (4/11/35) (*b*) 1.023 (22/4/36)	Not much character, but a clean, neutral cider.
Slack-ma-Girdle. (Newton St. Cyres, Devon)	1.047 (22/11/35)	M. 0.29 T. 0.13 F. 6.0	(*a*) 1.025 (3/1/36) (*b*) 1.024 (22/4/36). .	A very good, full-flavoured cider with more character than usual for this variety.
Slack-ma-Girdle. (Shapwick, Som.)	1.054 (22/11/35)	M. 0.26 T. 0.14 F. 5.7	(*a*) 1.025 (13/1/36) (*b*) 1.024 (22/4/36)	A very good sweet cider, but with rather less character than the previous sample.
Sweet Alford. (Woodbury, Devon)	1.051 (11/11/35)	M. 0.13 T. 0.18 F. 4.4	(*a*) 1.025 (8/2/36) (*b*) 1.025 (22/4/36)	A pleasant cider, but lacking body.
Sweet Alford. (Crediton, Devon)	1.050 (11/11/35)	M. 0.13 T. 0.16 F. 2.6	(*a*) 1.025 (14/3/36) (*b*) 1.024 (22/4/36)	Below the usual Sweet Alford standard, but with more character than the previous sample.
Sweet Alford. (Newton St. Cyres, Devon)	1.051 (11/11/35)	M. 0.14 T. 0.14 F. 4.0	(*a*) 1.025 (13/3/36) (*b*) 1.024 (22/4/36)	Moderate in quality and possessing a rather soapy after-taste.
Sweet Alford. (Newton St. Cyres, Devon)	1.050 (11/11/35)	M. 0.15 T. 0.13 F. 3.0	(*a*) 1.025 (4/3/36) (*b*) 1.024 (22/4/36)	A cider of moderate quality.
Woodbine. (Charlton Adam, Som.)	1.051 (22/11/35)	M. 0.29 T. 0.14 F. 5.3	(*a*) 1.025 (27/12/35) (*b*) 1.025 (22/4/36)	A very good cider, soft and pleasant in flavour and rich in apple aroma.
Woodbine. (Babcary, Som.)	1.054 (2/12/35)	M. 0.29 T. 0.14 F. 8.5	(*a*) 1.025 (28/12/35) (*b*) 1.025 (22/4/36)	A high quality cider; quite full in flavour for its type.
Woodbine. (Kittisford, Som.)	1.055 (2/12/35)	M. 0.27 T. 0.25 F. 6.8	(*a*) 1.025 (6/1/36) (*b*) 1.024 (22/4/36)	A very good cider, but with a bitter character much above the normal for this variety.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (*a*) Time of Filtering. (*b*) Date of Judging. (April 22/36).	Notes on Ciders.
CLASS 3B.—SWEET VARIETIES which have not previously obtained prizes in these competitions.				
Brown Sweet. (Hewish, Som.)	1.046 (20/11/35)	M. 0.31 T. 0.13 F. 5.5	(*a*) 1.025 (3/1/36) (*b*) 1.025 (22/4/36)	A good quality cider, very pleasant in flavour although rather high in acidity. An interesting variety new to these competitions.
Cadbury. (North Cadbury, Som.)	1.042 (20/11/35)	M. 0.27 T. 0.14 F. 5.0	(*a*) 1.025 (29/11/35) (*b*) 1.025 (22/4/36)	A cider with very little character.
Clusters. (Kittisford, Som.)	1.045 (20/11/35)	M. 0.24 T. 0.15 F. 5.0	(*a*) 1.025 (3/12/35) (*b*) 1.025 (22/4/36)	Fuller in flavour than the previous sample, but still lacking character.
French Blanche. (Tregare, Mon.)	1.044 (18/10/35)	M. 0.17 T. 0.16 F. 3.2	(*a*) 1.025 (1/2/36) (*b*) 1.025 (22/4/36)	New to these competitions and a pleasant, soft, neutral-flavoured cider; worthy of further examination.
Maunder's Sweet. (Kingweston, Som.)	1.045 (20/11/35)	M. 0.20 T. 0.15 F. 6.5	(*a*) 1.025 (11/12/35) (*b*) 1.024 (22/4/36)	Poor quality; lacking character.
Vallis. (Easton-in-Gordano, Som.)	1.042 (18/10/35)	M. 0.23 T. 0.14 F. 5.4	(*a*) 1.025 (9/11/35) (*b*) 1.025 (22/4/36)	Pleasant and clean, but not outstanding in quality.

Bittersweet Varieties.—Acidity normally below 0.45 per cent. and tannin above 0.20 per cent.

Class 4a.—Bittersweet Varieties which have previously obtained prizes in these competitions.

Cherry Norman. (Norton Canon, Hereford)	1.064 (7/11/35)	M. 0.21 T. 0.24 F. 7.0	(*a*) 1.025 (2/1/36) (*b*) 1.024 (22/4/36)	A rich, medium bittersweet cider, full in flavour and very fruity.
Dabinett. (Burghill, Hereford)	1.051 (22/11/35)	M. 0.16 T. 0.27 F. 7.7	(*a*) 1.025 (4/1/36) (*b*) 1.024 (22/4/36)	A very good cider with a pleasant, soft, tannin character.
Dove. (Shapwick, Som.)	1.055 (29/11/35)	M. 0.23 T. 0.30 F. 6.2	(*a*) 1.025 (27/11/35) (*b*) 1.025 (22/4/36)	Moderate in quality.
Dove. (Kingweston, Som.)	1.052 (29/10/35)	M. 0.20 T. 0.30 F. 6.3	(*a*) 1.025 (29/11/35) (*b*) 1.025 (22/4/36)	Rather thin in flavour; lacking character.
George James (North Cadbury, Som.)	1.052 (11/11/35)	M. 0.18 T. 0.20 F. 3.4	(*a*) 1.025 (10/12/35) (*b*) 1.025 (22/4/36)	A fairly good cider, but inclined to be a little hard in flavour.
Hangdown. (Hewish, Som.)	1.048 (25/10/35)	M. 0.25 T. 0.20 F. 4.5	(*a*) 1.025 (20/11/35) (*b*) 1.025 (22/4/36)	A very mild bittersweet cider; pleasant, but rather watery.
Hangdown. (Shapwick, Som.)	1.043 (20/11/35)	M. 0.24 T. 0.21 F. 3.0	(*a*) 1.025 (21/1/36) (*b*) 1.025 (22/4/36)	A good quality cider, but having very little bitter character for this variety.
Knotted Kernel. (Norton Canon, Hereford)	1.065 (7/11/35)	M. 0.32 T. 0.26 F. 6.2	(*a*) 1.025 (29/1/36) (*b*) 1.024 (22/4/36)	A cider of high quality, very full in flavour with a refined tannin character.
Perthyre (Belle Norman). (Barton St. David, Som.)	1.053 (25/10/35)	M. 0.20 T. 0.17 F. 4.8	(*a*) 1.025 (25/11/35) (*b*) 1.024 (22/4/36)	A cider with a pleasant apple flavour, but not very full-bodied.

CLASS 4A.—BITTERSWEET VARIETIES—*continued.*

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (*a*) Time of Filtering. (*b*) Date of Judging. (April 22/36).	Notes on Ciders.
Perthyre (Belle Norman). (Dingestow, Mon.)	1.056 (25/10/35)	M. 0.29 T. 0.18 F. 5.7	(*a*) 1.025 (15/11/35) (*b*) 1.023 (22/4/36)	A pleasant, very mild bittersweet cider, but lacking fullness of flavour.
Perthyre (Belle Norman). (Norton Canon, Hereford)	1.051 (7/11/35)	M. 0.21 T. 0.20 F. 6.0	(*a*) 1.025 (12/12/35) (*b*) 1.024 (22/4/36)	Of poorer quality than the preceding cider ; not very pleasant.
Perthyre (Belle Norman). (Tarrington, Hereford)	1.049 (8/11/35)	M. 0.17 T. 0.20 F. 7.0	(*a*) 1.025 (28/11/35) (*b*) 1.022 (22/4/36)	A very good, mild, bittersweet cider.
Royal George. (Easton-in-Gordano, Som.)	1.048 (18/10/35)	M. 0.33 T. 0.20 F. 4.2	(*a*) 1.025 (10/1/36) (*b*) 1.025 (22/4/36)	A fair cider, but rather acid for this class.
Royal Jersey. (Shapwick, Som.)	1.047 (7/11/35)	M. 0.18 T. 0.42 F. 2.5	(*a*) 1.025 (30/1/36) (*b*) 1.024 (22/4/36)	A good bittersweet cider with a very pronounced tannin flavour, but valuable for blending purposes.
Royal Jersey. (Somerton, Som.)	1.054 (7/11/35)	M. 0.18 T. 0.40 F. 4.3	(*a*) 1.025 (6/1/36) (*b*) 1.025 (22/4/36)	Very similar to the previous sample.
Royal Jersey. (Barton St. David, Som.)	1.058 (8/11/35)	M. 0.24 T. 0.38 F. 6.9	(*a*) 1.025 (3/1/36) (*b*) 1.024 (22/4/36)	Of a softer and less pronounced tannin flavour than the two previous ciders.

CLASS 4A.—BITTERSWEET VARIETIES—*continued*

Royal Wilding. (Shucknall Court, Hereford)	1.060 (21/11/35)	M. 0.20 T. 0.32 F. 7.3	(*a*) 1.025 (4/1/36) (*b*) 1.024 (22/4/36)	A very good cider and a useful type for blending purposes.
Shapwick Bitter. (Shapwick, Som.)	1.053 (20/10/35)	M. 0.23 T. 0.32 F. 4.0	(*a*) 1.025 (28/12/35) (*b*) 1.025 (22/4/36)	An inferior cider, with a trace of taint in flavour.
Strawberry Norman. (Dymock, Glos.)	1.061 (11/11/35)	M. 0.20 T. 0.40 F. 5.6	(*a*) 1.025 (22/1,36) (*b*) 1.024 (22/4/36)	A fair cider, but with the tannin flavour rather coarse.
Strawberry Norman. (Tarrington, Hereford)	1.058 (21/11/35)	M. 0.23 T. 0.48 F. 8.2	(*a*) 1.025 (21/12/35) (*b*) 1.022 (22/4/36)	A cider with a very hard tannin character.
Strawberry Norman. (Chaceley, (Glos.)	1.061 (21/11/35)	M. 0.28 T. 0.42 F. 5.5	(*a*) 1.025 (10/1/36) (*b*) 1.024 (22/4/36)	A fair cider with slightly softer tannin flavour than the previous samples of this variety.
Strawberry Norman. (Burghill, Hereford)	1.058 (21/11/35)	M. 0.23 T. 0.44 F. 7.7	(*a*) 1.025 (2/1/36) (*b*) 1.022 (22/4/36)	A cider with an umpleasant tannin flavour.
White Norman. (Norton Canon, Hereford)	1.055 (22/10/35)	M. 0.21 T: 0.21 F. 8.0	(*a*) 1.025 (12/11/35) (*b*) 1.022 (22/4/36)	A pleasant cider, but lacking character.
White Norman. (Tarrington, Hereford)	1.056 (7/11/35)	M. 0.17 T. 0.26 F. 5.7	(*a*) 1.025 (1/1/36) (*b*) 1.024 (22/4/36)	A very palatable bittersweet cider with a pleasant apple flavour and aroma.
Yarlington Mill Jersey. (Burghill, Hereford)	1.048 (11/11/35)	M. 0.09 T. 0.22 F. 2.4	(*a*) 1.025 (10/12/35) (*b*) 1.020 (22/4/36)	Cider " sickness " had developed in this cider before the date of judging.
Yarlington Mill Jersey. (North Cadbury, Som.)	1.043 (22/11/35)	M. 0.19 T. 0.24 F. 4.5	(*a*) 1.025 (28/12/35) (*b*) 1.025 (22/4/36)	A pleasant mild bittersweet cider, but not very full-flavoured.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (*a*) Time of Filtering. (*b*) Date of Judging. (April 22/36).	Notes on Ciders.
CLASS 4B.—BITTERSWEET VARIETIES which have not previously obtained prizes in these competitions.				
Broadleaf Jersey. (Martock, Som.)	1.051 (22/11/35)	M. 0.26 T. 0.26 F. 8.5	(*a*) 1.025 (19/12/35) (*b*) 1.023 (22/4/36)	A cider of very little character.
Bunch Jersey. (Barton St. David, Som.)	1.049 (29/10/35)	M. 0.22 T. 0.23 F. 3.8	(*a*) 1.025 (1/1/36) (*b*) 1.024 (22/4/36)	A fairly good cider; full in flavour.
Carter's Dove. (Keinton Mandeville, Som.)	1.045 (21/11/35)	M. 0.28 T. 0.22 F. 7.5	(*a*) 1.025 (2/12/35) (*b*) 1.023 (22/4/36)	Moderate in quality; lacking character.
Chisel Jersey. (North Cadbury, Som.)	1.045 (2/12/35)	M. 0.21 T. 0.31 F. 3.3	(*a*) 1.025 (16/12/35) (*b*) 1.024 (22/4/36)	A very good bittersweet cider, but the tannin flavour was rather hard
Cummy Norman. (Norton Canon, Hereford)	1.062 (7/11/35)	M. 0.20 T. 0.29 F. 9.2	(*a*) 1.025 (4/12/35) (*b*) 1.022 (22/4/36)	A very pleasant, full-flavoured bittersweet cider.
Edward's Bitter. (Norton Canon, Hereford)	1.059 (7/11/35)	M. 0.25 T. 0.33 F. 9.0	(*a*) 1.025 (7/12/35) (*b*) 1.024 (22/4/36)	A moderate cider with a hard tannin flavour.
Harry Master's Jersey. (North Cadbury, Som.)	1.051 (2/12/35)	M. 0.16 T. 0.23 F. 7.3	(*a*) 1.025 (7/1/36) (*b*) 1.021 (22/4/36)	A good quality bittersweet cider, with a very soft, tannin flavour.
Jenning's Jersey. (Shapwick, Som.)	1.055 (22/11/35)	M. 0.19 T. 0.36 F. 7.5	(*a*) 1.025 (30/12/35) (*b*) 1.018 (22/4/36)	Quality poor and the tannin flavour coarse.

CLASS 4B.—BITTERSWEET VARIETIES—*continued.*

Medaille d'Or. (Tarrington, Hereford)	1.056 (21/11/35)	M. 0.21 T. 0.67 F. 6.2	(*a*) 1.025 (14/12/35) (*b*) 1.024 (22/4/36)	An inferior cider; although a high tannin content is expected in this variety, the bitter flavour was very unpleasant in this case.
Shapwick Apple. (Shapwick, Som.)	1.051 (21/11/35)	M. 0.20 T. 0.23 F. 5.2	(*a*) 1.025 (29/1/36) (*b*) 1.023 (22/4/36)	A cider with a peculiar flavour and aroma; not very pleasant.
Sweet Jersey. (Somerton, Som.)	1.058 (29/10/35)	M. 0.19 T. 0.25 F. 6.0	(*a*) 1.025 (4/12/35) (*b*) 1.024 (22/4/36)	A good-flavoured mild bittersweet cider; not very full-bodied.
Tom Tanners. (Hewish, Som.)	1.060 (8/11/35)	M. 0.31 T. 0.59 F. 4.2	(*a*) 1.025 (24/2/36) (*b*) 1.024 (22/4/36)	A heavy, dark coloured cider with an extremely pronounced tannin flavour. Used in small proportions it was useful for blending purposes.
White Styre. (Ashleworth, Glos.)	1.049 (21/11/35)	M. 0.25 T. 0.21 F. 4.0	(*a*) 1.025 (14/12/35) (*b*) 1.024 (22/4/36)	An exceptionally soft, pleasant cider, but a very mild bittersweet type: rather light in character.
Wilding. (Tarrington, Hereford)	1.045 (21/11/35)	M. 0.28 T. 0.23 F. 5.5	(*a*) 1.025 (13/12/35) (*b*) 1.023 (22/4/36)	A fair cider.

CLASS 5.—PERRIES.

Blakeney Red. (Axbridge, Som.)	1.049 (18/10/35)	M. 0.49 T. 0.11 F. 3.5	(*a*) 1.030 (11/1/36) (*b*) 1.029 (22/4/36)	A pleasant, clean perry, light in flavour.
Blakeney Red. (Norton Canon, Hereford)	1.049 (22/10/35)	M. 0.48 T. 0.10 F. 4.4	(*a*) 1.030 (27/11/35) (*b*) 1.029 (22/4/36)	Pleasant, soft and fruity in flavour; fuller than the previous sample.
Butt. (Chaceley, Glos.)	1.062 (14/11/35)	M. 0.58 T. 0.36 F. 3.2	(*a*) 1.030 (9/3/36) (*b*) 1.028 (22/4/36)	Of poor quality; very hard and coarse in flavour.

COMPETITIVE VARIETIES.

Variety.	Gravity of Fresh Juice and Date of Making.	Malic Acid (M) %, Tannin (T) %, and Rate of Fermentation (F).	Gravity at (*a*) Time of Filtering. (*b*) Date of Judging. (April 22/36).	Notes on Ciders.
CLASS 5.—PERRIES—*continued*.				
Butt. (Uckington, Glos.)	1.058 (14/11/35)	M. 0.52 T. 0.15 F. 2.2	(*a*) 1.030 (4/3/36) (*b*) 1.029 (22/4/36)	A very good, full-flavoured perry, with plenty of character and aroma, but lacking the astringency usually associated with this variety.
Holmer. (Holmer, Hereford)	1.067 (22/10/35)	M. 0.72 T. 0.11 F. 5.7	(*a*) 1.030 (6/1/36) (*b*) 1.029 (22/4/36)	Quality fair, but lacking in character and aroma.
Huffcap. (Ashleworth, Glos.)	1.079 (14/11/35)	M. 0.30 T. 0.68 F. 3.3	(*a*) 1.030 (16/3/36) (*b*) 1.029 (22/4/36)	A very harsh-flavoured perry, which developed a very "milky" turbidity.
Oldfield. (Peopleton, Worcs.)	1.064 (14/11/35)	M. 0.73 T. 0.11 F. 3.2	(*a*) 1.030 (26/2/36) (*b*) 1.029 (22/4/36)	Moderate in quality; far below the usual standard.
Runny Bob. (Upton Snodsbury, Worcs.)	1.054 (15/10/35)	M. 0.96 T. 0.06 F. 5.7	(*a*) 1.030 (6/11/35) (*b*) 1.029 (22/4/36)	A poor perry.
Squash Pear. (Ashleworth, Glos.)	1.059 (22/10/35)	M. 0.36 T. 0.07 F. 7.0	(*a*) 1.030 (18/11/35) (*b*) 1.027 (22/4/36)	A pleasant perry, although not very full in flavour.
Sugar Pear. (Leonard Stanley, Glos.)	1.049 (17/10/35)	M. 0.97 T. 0.18 F. 6.7	(*a*) 1.030 (23/11/35) (*b*) 1.029 (22/4/36)	Quality poor, with a very penetrating acid flavour.
Winnal's Longdon. (Bromsberrow, Worcs.)	1.062 (1/11/35)	M. 0.98 T. 0.14 F. 5.1	(*a*) 1.030 (4/12/35) (*b*) 1.028 (22/4/36)	A very acid perry, rather coarse in flavour.
Yellow Pear. (Peopleton, Worcs.)	1.064 (22/10/35)	M. 0.76 T. 0.10 F. 6.2	(*a*) 1.030 (6/1/36) (*b*) 1.028 (22/4/36)	Quality fair, but the acid flavour was too pronounced for use unblended.

COMPETITION CIDERS, 1935-36.

JUDGES' AWARDS.

CLASS 1.—KINGSTON BLACK. (11 *Entries*) (3 *Prizes*).

First Prize	H. C. Davis, Hewish, Som.
Second Prize	T. J. Frampton, Barton St. David, Som.
Third Prize	W. Hill, Kittisford, Som.
Reserve	J. Hewson, Somerton, Som.
Highly Commended	W. C. Carter, Keinton Mandeville, Som.
,, ,,	J. Maunder, Kingweston, Som.

CLASS 2A.—SHARP VARIETIES which have previously obtained prizes in these Competitions. (10 *Entries*) (4 *Prizes*).

		Variety.
Equal First Prize	W. H. Yard, Langport, Som.	Cap of Liberty.
,, ,, ,,	J. Maunder, Kingweston, Som.	Lambrook Pippin.
Equal Second Prize	C. H. Sherrin, Martock, Som.	Cap of Liberty.
,, ,, ,,	T. J. Frampton, Barton St. David, Som.	Lambrook Pippin.
Reserve	A. Pope, Crediton, Devon	Langworthy.

CLASS 2B.—SHARP VARIETIES which have not previously obtained prizes in these Competitions. (4 *Entries*) (1 *Prize*).

First Prize	T. G. Bullock, Easton-in-Gordano, Som.	Bastard Tom Putt.
Reserve	H. Moore, Shucknall Court, Hereford	Cherry Pearmain.
Commended	C. A. Jennings, Shapwick, Som.	Neverblight.

CLASS 3A.—SWEET VARIETIES which have previously obtained prizes in these Competitions (10 *Entries*) (2 *Prizes*).

First Prize	A. H. Walters, Newton St. Cyres, Devon	Slack-ma-Girdle.
Second Prize	G. P. Hallett, Charlton Adam, Som.	Woodbine.
Reserve	Major C. Jackson, Charlton Mackrell, Som.	Jackson's White.
Very Highly Com'ded	J. A. Bartlett, Babcary, Som.	Woodbine.
Highly Commended	C. A. Jennings, Shapwick, Som.	Slack-ma-Girdle.

CLASS 3B.—SWEET VARIETIES which have not previously obtained prizes in these Competitions. (6 *Entries*) (1 *Prize*).

First Prize	H. C. Davis, Hewish, Som.	Brown Sweet.
Reserve	S. W. Jones, Tregare, Mon.	French Blanche.
Very Highly Com'ded	T. G. Bullock, Easton-inGardano, Som.	Vallis.

CLASS 4A.—BITTERSWEET VARIETIES which have previously obtained prizes in these Competitons. (26 *Entries*) (3 *Prizes*).

		Variety.
First Prize	H. C. Dent, Tarrington, Hereford	White Norman.
Second Prize	Mental Hospital, Burghill, Hereford	Dabinett.
Third Prize	F. Edwards, Norton Canon, Hereford	Cherry Norman.
Reserve	F. Edwards, Norton Canon, Hereford	Knotted Kernel.
Very Highly Com'ded	H. Moore, Shucknall Court, Hereford	Royal Wilding.
Highly Commended	H. C. Dent, Tarrington, Hereford	Perthyre.
,, ,,	T. J. Frampton, Barton St. David, Som.	Royal Jersey.
,, ,,	E. T. Lewis, Dymock, Glos.	Strawberry Norman
Commended	H. C. Davis, Hewish, Som.	Hangdown.
,,	C. A. Jennings, Shapwick, Som.	Hangdown.
,,	T. J. Frampton, Barton St. David, Som.	Perthyre.
,,	S. J. Mullins, Dingestow, Mon.	Perthyre.

CLASS 4B.—BITTERSWEET VARIETIES which have not previously obtained prizes in these Competitions. (14 *Entries*) (3 *Prizes*).

First Prize	G. W. Fowler, Ashleworth, Glos.	White Styre.
Second Prize	S. H. Osborn, North Cadbury, Som.	Harry Master's Jersey.
Third Prize	F. Edwards, Norton Canon, Hereford	Cummy Norman.
Reserve	S. H. Osborn, North Cadbury, Som.	Chisel Jersey.
Very Highly Com'ded	M. R. Adams, Somerton, Som.	Sweet Jersey.
Highly Commended	H. C. Dent, Tarrington, Hereford	Wilding.

CLASS 5.—PERRIES. (12 *Entries*) (3 *Prizes*).

First Prize	T. H. Brookes, Uckington, Glos.	Butt.
Second Prize	P. T. Prosser, Norton Canon, Hereford	Blakeney Red.
Third Prize	F. Pole, Holmer, Hereford	Holmer.
Reserve	G. W. Fowler, Ashleworth, Glos.	Squash Pear.
Commended	P. M. Frost, Axbridge, Som.	Blakeney Red.
,,	J. F. Bomford, Peopleton, Worcs.	Oldfield.
,,	J. F. Bomford, Peopleton, Worcs.	Yellow Pear.

INVESTIGATIONS ON FRUIT PRODUCTS.

IX.—CHEMICAL CONSTITUENTS OF FRESH JUICES FROM SINGLE VARIETIES OF SOFT FRUITS, AND THE SUITABILITY OF THE JUICES FOR SYRUP MANUFACTURE.

By VERNON L. S. CHARLEY.

The preceding investigations in this series have all been concerned with the manufacture of a number of liquid fruit products which have been made from bulks of soft fruits, in many cases of which the varieties present were unknown. At the present stage of the new fruit products industry, it is obvious that any differences of importance which are due to the individual varieties should be ascertained, and consequently during the summer of 1936 a preliminary programme was carried out, making use of such single varieties of soft fruits as were available from the plantations of the Research Station. Although the list of varieties is by no means exhaustive, the information gained has already been of much use to manufacturers of pure fruit syrups. The results which are presented at this stage will be extended in future Reports to include as many varieties as possible of commercial importance.

The chemical data with which this report is partly concerned refer to acidity, " tannin " (permanganate reducing figure), ash and ascorbic acid (Vitamin C) of a series of fresh juices obtained from a number of single varieties of soft fruits. Specific gravity determinations were also carried out on the juices and the report also includes details of the aroma and flavour of syrups made from the juices.

Experimental.

With the exception of the cherry, blackberry and wortleberry fruits, all the raw material for the experiments was obtained from the Research Station variety trial plots. The fruit was gathered in a ripe condition and was then immediately milled. A very small quantity of the thoroughly mixed, milled fruit was removed from the bulk sample and the juice expressed and analysed for specific gravity, acidity, " tannin," ash and ascorbic acid. The ascorbic acid determination was carried out on the freshly expressed juice by means of Tillmann's indicator, 2:4 dichlorophenol-indophenol. No difficulty was found with the end-point when using the method of Harris and Ray (2).

The remainder of the pulped fruit was allowed to undergo a slight fermentation and the juice was then expressed and filtered. The syrups were made by the incorporation of solid sugar in the filtered juices until a 50% concentration was achieved. The sweetened products were stabilised with SO_2. The observations on flavour were made 9 months after the preparation of the syrups.

The results are given in Table I.

Discussion.

Juice Analyses.

The accuracy of the specific gravity figures for the fresh juices was vitiated by the onset of fermentation, and as the alcohol was not determined the data do not give the exact original gravities of the juices. The figures given in the following article in this Report (p. 213) are corrected for alcohol formation and no original gravities were found to be less than 1.030 in the case of any fruit.

It was not possible to determine the specific gravities of the black currant juices by the hydrometer on account of their very viscous nature. The gravities of fresh black currant juices from large bulks of fruit are given in the article mentioned above and range from 1.050—1.054.

The acidity data call for little comment whilst the tannin contents, with the exception of black currants where the values are high, vary only slightly from fruit to fruit. The Edina black currant juice was notably high in tannin and the syrup possessed the most fully developed aroma of all the varieties examined.

Ash content of the juices of single varieties of soft fruit juices are presented here for the first time. Black currant juices contain the largest percentages of ash as well as acid and tannin.

The ascorbic acid (Vitamin C) data are of special interest. For purposes of comparison it is of interest to record the values for ascorbic acid determined by other workers for lemon and orange juice. The results for oranges vary considerably with the country of origin of the fruit, but the following list of results obtained recently by Olliver (1) include all the important types of this fruit.

TABLE I.

ANALYSES OF SINGLE VARIETY FRUIT JUICES AND CHARACTERS OF SYRUPS MADE THEREFROM.

Fruit.	*Variety.*	*Date.*	*Analyses of Fruit Juices.* Specific Gravity.	Acidity as Citric Acid per cent.	"Tannin" per cent.	Ash per cent.	Ascorbic Acid mgrs/100 cc.	*Characters of Fruit Syrups.* Aroma.	Flavour.
Strawberry ..	Royal Sovereign ..	25/6/36	1.024	0.82	0.11	0.548	52.9	Full and pleasant.	Characteristic, full-bodied and soft.
	Oberschlesien ..	29/6/36	1.020	0.86	0.14	0.400	64.0	Slight.	Aromatic but weak.
	Tardive de Leopold ..	1/7/36	1.020	0.88	0.14	0.548	40.0	,,	As for Royal Sovereign.
	Pillnitz	3/7/36	—	1.21	0.17	0.442	—	,,	Inferior flavour. Not characteristic of fruit.
Raspberry ..	Lloyd George ..	11/7/36	1.025	2.20	0.12	0.497	22.5	Full and true to fruit.	Splendid rich flavour.
	Preussen	11/7/36	1.023	1.86	0.13	0.430	24.7	Very full scented aroma.	Remarkably aromatic and scented.
	Viking	14/7/36	1.033	1.84	0.14	0.390	32.6	Slight	Flat. Uninteresting.
	Improved Bee-hive ..	14/7/36	1.025	1.85	0.12	0.354	28.0	,,	Remarkably rich aromatic flavour.
	Duke of Cornwall ..	14/7/36	1.025	1.77	0.15	0.437	25.9	Good.	Similar to Lloyd George but slightly less intense.
	A.R.C. 18	14/7/36	1.027	1.86	0.14	0.388	33.8	Slight, but clean and fruity.	Pleasant.
	Norfolk Giant ..	14/7/36	1.016	2.18	0.19	0.448	20.8	,, ,, ,,	,, . Rather weak.
	Brocket Hall	14/7/36	1.023	1.59	0.18	0.470	22.4	,, ,, ,,	Fair. Clean but not intense.
Black Currant	Baldwin	16/7/36	—	3.40	0.24	0.574	161.0	Clean & fruity but not intense.	Clean and characteristic. Not intense.
	Boskoop	16/7/36	—	3.20	0.23	0.516	132.0	,, ,, ,,	,, ,, ,,
	French	16/7/36	—	2.86	0.33	0.416	128.0	,, ,, ,,	Full flavoured with scented character.
	Edina	16/7/36	—	3.34	0.46	0.533	99.0	Full and aromatic.	Full characteristic flavour.
	Taylor	16/7/36	—	—	—	0.703	—	Not fully characteristic.	Fair.
	Westwick	16/7/36	—	2.91	0.25	0.683	147.4	Full aroma.	More character. Full and clean.
Red Currant ..	Red Defiance ..	9/7/36	1.038	2.30	0.15	0.461	35.7	Slight and completely lacking in true fruit character.	Clean and soft. No red currant flavour.
	Laxton's No. 1 ..	9/7/36	1.031	2.15	0.15	0.483	51.8	,, ,, ,,	Full and fresh. No red currant flavour.
	Laxton's Monarch ..	9/7/36	1.041	2.55	0.15	0.474	50.0	,, ,, ,,	Lacking in fruit character.
	Comet	9/7/36	1.033	2.54	0.15	0.504	45.9	,, ,, ,,	Poor.
	Northern Star ..	9/7/36	1.033	2.75	0.16	0.627	46.9	,, ,, ,,	As for Laxton's No. 1.
	Raby Castle	9/7/36	1.041	2.73	0.17	0.490	40.0	,, ,, ,,	Poor.
	Laxton's Perfection ..	9/7/36	1.035	2.52	0.15	0.532	38.7	,, ,, ,,	,,
Gooseberry ..	May Duke		1.047	2.03	0.12	0.329	27.2	Slight.	Pleasant. Lacking in intensity of fruit character.
	Gautrey's Earliest ..		1.045	1.94	0.11	0.335	27.3	,,	Very slight flavour.
	Lancashire Lad ..		1.044	2.10	0.14	0.323	27.3	,,	,, ,, ,,
Cherry ..	Napoleon		1.064	0.77	0.19	0.464	trace	,,	,, ,, ,,
Whortleberry*	—		1.040	1.40	0.20	0.308	16.9	,,	Full fruity character.
Blackberry* ..	—		1.032	2.00	0.28	0.411	trace	,,	True to fresh fruit, but not intense.

* Mixed fruit picked from Mendip Hills, Somerset.

Ascorbic Acid Content of Orange Juices from various sources. (after Olliver.)

Variety.	*Limiting values found for Ascorbic Acid (mgs./100 cc. of juice).*
Seville	18.9—45.5
Jaffa	33.3—53.7
Brazilian	52.6—62.5
Spanish Burriana	52.2—66.0
,, Valencia	50.0
California	63.2—70.6
South Africa	76.9

Harris & Ray (2) obtained as mean values from a wide range of varieties of oranges and lemons the figures 63 and 47 mgs/100 cc. respectively. Bacharach, Cook & Smith (3) gave the mean values as 51 mgs./100 cc. for orange juice, and 64 mgs./100 cc. for lemon juice.

For the purposes of comparison with English soft fruit juices, the ascorbic acid content for lemon and orange juices can thus be taken as approximately 55 mgs./100 cc. for both juices.

The average figures obtained at Long Ashton for the varieties of the different fruits are given below :—

	Samples Examined.	*Mgs. Ascorbic Acid per 100 cc. juice.*
Strawberry	3	52.0
Raspberry	8	26.3
Black Currant	6	143.5
Red Currant	7	44.1
Gooseberry	3	27.3
Cherry (Napoleon)	1	trace.
Whortleberry	1	16.9
Blackberry	1	trace.
(Lemon		55)

The figures indicate that black currant juices contain on an average nearly three times as much ascorbic acid as lemon juice, whilst the juice from strawberries is equally rich as the latter in this constituent. The analysis for red currant is of interest, as considerable supplies of this fruit are usually available.

The data presented above for the first time show that the supposed superiority of citrus juices over all other types is fictitious and the remarkably high Vitamin C content of black currant, together with the high values for strawberry and red currant juices, indicate that there are distinct possibilities of utilising such juices as sources of this accessory food factor, provided that suitable means of preservation can be adopted. The whole question of the stability of ascorbic acid under the storage conditions usually employed for syrups is under investigation.

Character of Syrups made from Single Variety Juices.

Certain well-defined differences in flavour were noted when the syrups were tasted. In the case of strawberries, Royal Sovereign provided the best syrup, followed closely by Tardive de Leopold, which was slightly deficient in aroma.

In the raspberry series, the most interesting syrups were made from Preussen and Improved Bee-hive juices. Both were remarkably scented and despite their lack of aroma, gave the most characteristic and intense suggestion of true and fresh raspberry flavour.

The success of the Preussen variety will possibly be of general interest to raspberry growers, for the canes are heavy croppers and the variety is now being planted up to a considerable extent.

Two commercially important varieties of black currants, Baldwin and Boskoop, did not yield syrups with any specially notable features. The sweetened products were clean, with the characteristic taste of cold black currants noticeable, but not intense. French and Edina, however, gave syrups with richer flavours and more intensely flavoured with the true fruit character. Westwick gave a similar type of syrup.

The syrups of the red currant varieties were remarkably similar in character. No trace of any characteristic fruity aroma was detected in the syrups, and the flavours were, in general, soft and pleasant without being reminiscent in any way of the fruit in question. Laxton's No. 1 and Northern Star gave the best syrups, whilst Comet and Raby Castle syrups were definitely disappointing.

Amongst the three gooseberry syrups, only May Duke possessed any characteristic flavour whatever. The other syrups were pleasant, but devoid of any interest. The aerated and diluted May Duke syrup was a very attractive beverage, but the remainder merely tasted of sugar and acid. The variety Careless was unfortunately omitted from the series.

Summary.

1. Some chemical analyses are presented for juices from single varieties of British grown soft fruits.
2. The ascorbic acid (Vitamin C) content of black currant juices was shown to be about three times as great as for lemon juice. Strawberry juices contained quantities equal to lemon juice, whilst red currant juices contained about 80% of the ascorbic acid in citrus juice. Other juices gave various lower figures.
3. The most attractive syrups were made from Royal Sovereign and Tardive de Leopold strawberries; Preussen, Improved Bee-hive and Lloyd George raspberries; French, Edina and Westwick black currants; Laxton's No. 1 and Northern Star red currants; and May Duke gooseberries.

Acknowledgment.

The writer wishes to acknowledge the valuable help given by Mr. L. G. Darch, B.Sc., who was responsible for the chemical data presented in this article.

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INVESTIGATIONS ON FRUIT PRODUCTS.

X.—THE COMMERCIAL PRODUCTION OF FRUIT SYRUPS.

By VERNON L. S. CHARLEY.

During the summer of 1932, a series of investigations was commenced in the Fruit Products Section of this Station which dealt with new outlets for fruit by its conversion into various stable liquid products. Fruit syrups were amongst the products examined in the initial experiments and the attractiveness and promise of these caused special attention to be paid subsequently to the fuller details of their manufacture.

The results of these investigations were published in two articles in the Annual Reports of this Station for 1932 and 1935. A series of recommendations was given therein on methods for the production of syrups for general use, whilst the latter report also indicated some precautions to be observed in the processing of fruit into syrups for use with milk.

As a direct result of these investigations, several firms commenced to manufacture pure fruit syrups during the summer of 1936. Several small plants were installed by fruit growers in Worcestershire and Suffolk to deal with their own surplus fruit, whilst a fruit dealer in Wisbech made larger quantities from various local sources of supply. The largest plant, however, was installed by a Bristol firm, Messrs. H. W. Carter & Co., Ltd., syrup and squash manufacturers, who decided to equip a new factory to be used entirely for the large scale production of fruit syrups. A section of a modern disused brewery at Ashton Gate, Bristol, was acquired for the purpose. Since the processing was to follow closely the recommendations of the Long Ashton Station, and the products were to qualify for the National Mark of the Ministry of Agriculture, an arrangement was made between the Ministry, the University of Bristol and Messrs. Carter under which the writer was enabled to take over the technical control of the first season's processing and to carry out any large-scale experiments considered necessary.*

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* The writer wishes to record his appreciation of the help and encouragement given to him by the Directors of Messrs. Carter during the 1936 fruit season when many working difficulties arose, and for permission to publish this Report of the work carried out at their Factory.

The recommendations contained in the 1935 Report were taken as the basis of production, and although many alterations in details were necessary during the course of the 1936 season, the Long Ashton cold-process method was satisfactorily applied to factory-scale production.

In the present account the general position during the 1936 soft fruit season, as it concerned the supplies of fruit and the effect of the unfavourable weather conditions on fruit quality, are reviewed first. Then follows a discussion of the various factory processes and observations on important points relating to the character and stability of the syrups.

Fruit Supplies.

When preliminary enquiries were being made with regard to the purchase of about 200 tons of soft fruits (strawberries, loganberries and black currants) of a suitable standard of quality, it was quickly seen that the position in respect of available supplies of the appropriate character was considerably different from what the writer had been led to expect from previous enquiries—so far as the 1936 crop was concerned at any rate. The main motive under which the investigations on fruit products at Long Ashton had been commenced was to relieve the general fruit marketing situation by providing an outlet for fruit of the lower grades. When, however, definite attempts were made in the actual fruit season to purchase bulks of fruit of that class at a suitable price it was found to be quite impossible. In the case of the strawberry, where 85 tons were needed, every consignment was purchased in the open market at approximately jam fruit prices. The writer and several prospective manufacturers had been assured by fruit growers and County horticultural officers in the previous season that there should be no difficulty in obtaining fruit of the class in question for the first year's requirements of the factory at an average price of £20 per ton. Actually, the average price paid per ton of fruit at the Ashton Gate factory for the 1936 summer season was approximately £35.

There were several features of special importance which may have contributed to the high prices of the various soft fruits in 1936. In the first place, there were short crops of strawberries and black currants, and in the case of the former fruit the picking season was completely disorganised by unfavourable weather conditions. In the Wisbech district, in particular, frequent thunderstorms destroyed large quantities of fruit and made the harvesting of ripened berries a matter of difficulty. These facts, although they account to some extent for the shortage of supplies up to the fresh fruit market standards, can in no way be responsible for the absence of lower grade fruit, for weather conditions of this kind are known to be amongst the most important causes of blemished berries which are of little use to the canners and jam-makers.

Rain was also responsible for fluctuations in the prices of Scotch raspberries, for although at the commencement of the season it was anticipated that there would be a good crop, this was not the case and prices hardened during the season.

Black currant growers experienced a very short crop, although most of the fruit was of very high quality. The special excellence in character of the syrup made at Ashton Gate may be attributed to the fact that the whole of the fruit used was of the highest market quality, most of it being picked in plantations near the factory under favourable weather conditions.

However, despite the particular features of the 1936 soft fruit season, it would seem that a few tons of each fruit should have been available at a much lower price than was usually paid. The wholeness, uniformity and freedom from blemish of the fruit is of relatively little importance from the point of view of the products manufacturer, who is thus more favourably placed to take and pay for the complete crop from a given plantation than the canner or jam-maker, both of whom require sound berries or currants of a fairly consistent medium size.

The solution of the problem may lie in the organisation of a system for the pooling of any small bulks of fruit that may become unsaleable for the fresh fruit market from time to time and the collection of the bulked fruit for despatch to the products factory.

Fruit Condition.

Where the cold process of making syrups is being used, it is of prime importance that the fruit should be practically free from moulds, although wholeness of the fruit and, within limits, fermentation are not important. The bad weather conditions prevailing during most of the summer season of 1936 indicated that serious trouble might be experienced with mould growths, but this did not prove to be the case.

Strawberries. The bulk of the strawberries was received from Wisbech. They were contained in trays (holding 14 or 21 lb.) or flat, open tubs, each of which held approximately 40 lb. of fruit.

The weather conditions at Wisbech were reflected in the condition of the fruit as it reached Bristol after an overnight road journey of 12 hours. The experience of one particular fortnight of the season serves to illustrate this. During the first week a series of consignments of strawberries were received which were of good dessert quality. The fruit was in trays and no disintegration of the berries had occurred on arrival at the factory. During the second week, however, the heavy rainfall at Wisbech was responsible for the arrival of the fruit at Bristol in a fermenting condition, but no appreciable mould growth was discovered. The history of this fruit is continued in the next section.

Trial consignments of strawberries were received from a Herefordshire canning factory. These consisted almost entirely of underripe or small and misshapen berries. The fruit was quite sound, but the lack of maturity of the fruit adversely affected the ultimate flavour of the syrup.

When strawberries were dispatched in tubs, a considerable separation of juice usually occurred, and fermentation was in a slightly more advanced state than in fruit sent in trays, although the fermentation appeared to have largely suppressed any mould growth.

Raspberries. The greater part of the 50 tons of raspberries used was received from Blairgowrie in Scotland. The fruit was packed in 1 cwt. tubs provided with loosely fitting covers and arrived by rail 36 hours after dispatch from the fruit farms. The condition of the fruit was remarkably good in spite of a very considerable drainage of juice from the berries. Mould growth was negligible and confined to one or two small centres, which were always situated on hard aggregates of fruit raised above the level of the liquid. These could easily be removed and the casks, on being emptied, showed no other signs of mould growth. Fermentation had always taken place, and in some cases had proceeded until the fruit had an alcohol content of 1.3% : this, as will be seen below in connection with processing, was in no way a disadvantage. Wisbech raspberries in trays were also used, but only in small quantity : they were not up to the standard of the Scotch fruit.

Loganberries. All the loganberries were purchased from Herefordshire and Worcestershire. No trouble was experienced with the condition of the fruit in respect of mould growth, but it was only with difficulty that growers could be persuaded to leave the fruit on the bushes until the characteristic deep red colour, indicating full ripeness, had developed. Hard immature berries of light red colour proved quite unsuitable for syrup making, but from one batch of almost black, mature berries one of the most attractive and delightful syrups in the whole season's production was prepared.

Black Currants. The greater part of the supplies of this fruit was purchased locally. Seven tons of remarkably fine berries were thus obtained, the fruits being perfectly clean and free from fermentation and mould growth. On the other hand, black currants supplied the only case in which the writer felt it essential to advise refusal to accept delivery of a considerable consignment of fruit. The berries arrived covered with a thick layer of mould growth, the flavour of which was so predominant that the fruit was rejected without any hesitation.

FACTORY PROCESSES.

Milling.

The fruit was taken in the trays or tubs to the top floor of the factory and turned out on to a sorting table where decomposed berries and extraneous material were removed. The fruits were then passed through a grater mill similar in type to that now in common use for cider-making. The cylinder of the mill had been coated by the new "Metallising" process with a coherent layer of one thousandth of an inch of stainless steel: whilst most of this layer remained intact throughout the season, it would be advisable in future to increase the thickness to three or four thousandths of an inch. The mill reduced the berry fruits to a very fine mash. Black currants were considerably disintegrated, although there were a large number of berries of which the skins were merely broken into two portions and not completely torn to shreds.

Fermentation and Removal of Pectin.

The fruit pulp thus obtained was then permitted to ferment slightly to facilitate the removal of pectin. American workers have often recommended the use of heat as a means of removing colloidal substances from fruit juices but, in the case of pectin, heat only seems to accelerate the production of more soluble pectin from its insoluble precursor, protopectin, which is closely associated with the cell walls of the fruit tissues, thereby tending to cause serious trouble later. The earlier investigations at Long Ashton had shown, however, the efficiency of alcoholic fermentation in removing soluble pectin from the fruits and fruit juices. Consequently, at the beginning of the season, it was decided to use a controlled fermentation to effect this object, and generally to render the pulped fruit more amenable to the subsequent stage of processing.

The milling of the fruit as a preliminary operation, allowed a very definite separation of fruit tissues from fruit juice to take place soon after the onset of appreciable fermentation. This separation generally occurred after 12 hours in vat, although in some samples of strawberry—the fermenting consignments mentioned earlier in this report—the fruit tissues separated within two or three hours of milling.

Immediately any juice so separated was available, an alcohol determination was carried out and the actual specific gravity, together with the original gravity computed from the former figure and the alcohol content, were noted for purposes of the National Mark records. Specific gravities were very carefully watched until about 0.8—1.2% of alcohol by weight was found in the juice, at which stage the pulp was pressed out. In one or two cases the alcohol had risen to 1.3% by weight—Scotch and Herefordshire raspberries—but in no case was there sufficient alcohol to prejudice the use of the juice for making syrup.

The behaviour of the various fruits during the fermentation process will be considered separately.

Strawberries. These fruits responded remarkably to the fermentation process. Sound, dry, slightly immature berries were longer in commencing to ferment than those which had suffered wet conditions previous to being picked. One batch of this latter type proved to be most difficult in the processing. Soon after milling, the fruit tissue " climbed " in the 600 gallon vat and part of it overflowed and poured out of the vessel in the form of a viscous froth. The juice during this phase in the vat was in constant active motion, giving the appearance of boiling, and its temperature rose to 3.5°C. higher than that of the vat room. The addition of a preservative at this stage, instead of after the syruping of the juice later, and the immediate pressing of the juice from the fermenting mass were effective in arresting further fermentation and in enabling a syrup to be made which conformed to the law with respect to alcohol.

The juice which separated from the fruit tissue in the vat during fermentation was often practically clear, and in an effectively treated vat over 60% of the available juice could be drawn off from the bottom of the vat without carrying much tissue with it. This withdrawal of juice was highly important, as it left behind a bulk of tissue of semi-solid consistency, comparatively easy to press and giving a good yield of juice. Great difficulty was experienced in attempting to press a mass of tissue when the juice was not removed, owing to the instability of the "cheese," and poor yields of juice were inevitable.

The removal of pectin was noted from time to time by means of both the "alcohol precipitate" and the "calcium pectate" methods. When, however, the factory had been in production for a fortnight, it was obvious that the pectin had not been completely removed during the fermentation phase, as the syrups were all showing heavy flocculent deposits. It was thus decided to carry out trials on the use of Filtragol, a pectin-decomposing enzyme which had been previously tested at Long Ashton. The enzyme powder base was used throughout at a rate of 0.2%, 10 lb. being sifted into each 500-gallon vat immediately the fruit was milled. Chemical data indicated that the removal of pectin was greatly accelerated by the enzyme, and its use was made standard for the rest of the season's work.

Typical data for the analyses of fresh strawberry juices and for the removal of pectin by the joint fermentation-enzyme process are given below :—

ANALYSES OF STRAWBERRY JUICES.

Date.	*Quantity of milled fruit from which sample was taken.*	*Specific Gravity.*	*Alcohol per cent. by weight.*	*Tannin per cent.*
June 24th	3 tons.	1.032	0.2	0.11
,, ,, ...	4 ,,	1.032	0.3	0.13
,, 25th	5½ ,,	1.022	0.8	0.12
July 5th	6 ,,	1.020	0.67	0.12

REMOVAL OF PECTIN FROM STRAWBERRY JUICE BY THE JOINT ACTION OF FERMENTATION AND FILTRAGOL (0.2%).

Period of action of enzyme.	*Calcium pectate per cent. (average of 7 series of analyses).*
0 (Control).	0.147
12 hours.	0.033
24 ,,	0.007
30 ,,	trace

Raspberries. No difficulty was associated with the treatment of this fruit. Most of the Scotch fruit needed very little additional fermentation on its arrival, but where the fruit condition and temperature were favourable, the fruit was milled and the enzyme added. 36 hours were necessary to effect a complete removal of pectin from the juice, and in many batches it was not feasible to allow this period for the enzyme action owing to the risk of a rise in alcohol content above the permissible limit.

The analyses of some of the juices on arrival at the factory are given below :—

ANALYSES OF RASPBERRY JUICES.

Date.	*Quantity of milled fruit from which sample was taken.*	*Specific Gravity.*	*Alcohol per cent. by weight.*	*Tannin per cent.*	*Origin.*
July 5th ..	4 tons.	1.030	0.3	0.15	Blairgowrie.
,, 7th ..	4 ,,	1.020	1.1	0.13	,,
,, 10th ..	5 ,,	1.019	1.28	0.14	,,
,, 12th ..	5 ,,	1.026	1.0	0.15	Alyth (Scotland).
,, 18th ..	5 ,,	1.020	1.3	0.14	Hereford.

Loganberries. The higher specific gravity of loganberry juices and the immaturity of some of the fruit made the processing uneventful. Where possible the fruit was left in large 2—3 cwt. barrels to mature further before being milled.

ANALYSES OF LOGANBERRY JUICES.

Date.	*Quantity of milled fruit from which sample was taken.*	*Specific Gravity.*	*Alcohol per cent. by weight.*	*Tannin per cent.*
July 20th	3 tons	1.036	0.1	0.15
,, 24th	1½ ,,	1.041	0.2	0.14
,, 26th	1 ,,	1.032	0.4	0.15

Black Currants. It was practically impossible to treat this fruit in the cold without making use of enzymes. Fermentation was protracted and 5—8 days elapsed before the juice lost 8—10 points in gravity. During the fermentation process in the presence of enzymes, however, a very definite thinning down of the tissue was noticeable. It is of interest to note that the black currant syrups which were made in the 1936 season and were filtered to a brilliant condition during July (within a week of receipt of the fresh fruit) still retained their clarity nine months later. This contrasts with strawberry, raspberry and loganberry, in all of which deposits of variable extent have since been formed.

The enzyme was added to the fruit as it was being milled to ensure intimate contact between fruit and enzyme base. A very remarkable withdrawal of juice from the fruit tissue was effected by this means and the bulk of tissue remaining in the vats had lierally to be dug out for expression of the remaining juice.

The gravities of the juices were the highest of all the series for English fruits and the fresh, slightly fermented juice was remarkable for its intense and true fruit character.

ANALYSES OF BLACK CURRANT JUICES.

Date.	*Quantity of milled fruit from which sample was taken.*	*Specific Gravity.*	*Alcohol per cent. by weight.*	*Tannin per cent.*	*Origin.*
July 20th ..	7 tons.	1.054	0.1	0.34	Somerset.
.. 23rd ..	3 ,,	1.050	0.2	0.31	Hereford.

Enzyme Treatment.

Previous experience with enzyme preparations at Long Ashton had indicated the possibility of the enzyme completing its task after the filtration of the juice or syrup, this causing an unsightly deposit in the clear syrup. Special attention was paid to this point during the syrup-making season. Although the method described herein was extensively tried, it will be seen in a later section of this Report that, with the exception of black currant, further deposits were formed after filtration.

The length of time needed for the enzyme to complete its work appeared to be correlated with the pH of the juice, and each batch was examined separately to determine whether the pectin (as given by the Carré and Haynes calcium pectate method) still remained in the juice to any appreciable extent. Where it was at all possible, the enzyme was allowed to carry the decomposition of pectin to its completion ; but in some cases, where fermentation had already proceeded to some extent before the fruit arrived at the factory, it was quite impossible to allow a sufficient further period for the enzyme to have its full effect. It is probably due to this incomplete reaction that further pectin deposits occurred later in the history of the syrups.

Apart from the chemical method for determining the course of the pectin removal, it was found that viscometer readings were of considerable use. The data were easily obtained and the results were available in a much shorter time than the calcium pectate values. The viscosity of the juices fell rapidly as fermentation proceeded and at an even quicker rate where Filtragol was introduced. The rather surprising result was obtained that, as the pectin decomposition approached completion, the viscosity of the juice fell to a value only slightly greater than that for water determined by the same instrument. It became evident that, provided constant conditions are secured for the determination, the viscometer offers a valuable means of observing the course of enzyme action.

Juice Extraction.

After the required degree of fermentation had been reached, the juice underlying the layer of fruit tissue was drained away from the vats through a woollen cloth into the juice-collecting tanks. The solid tissue was then built up into a "cheese," exactly as in cider-making procedure, using the new type of woollen cloths with intermediate racks to facilitate drainage. A 120-ton hydraulic press was used, dealing with ½ ton of fruit at one pressing, which usually occupied half an hour. Strawberry alone amongst the four fruits presented any difficulty in this operation, and this was immediately overcome when the fermentation was controlled and an enzyme treatment adopted. The pressed residue was quite firm and, except with black currants, could easily be shaken out of the cloths. It was often noticed that this residue retained to a high degree the flavour and aroma of the fruit and it was obvious that in discarding it as a waste product for which no use hitherto had been found the makers of such products as these syrups may be missing a chance of intensifying the fruit flavour and aroma of the syrups.

The total yields of juice per ton of fruit approximated to the following :—

Strawberries	..	160 gallons.
Raspberries	..	150 ,,
Loganberries	..	150 ,,
Black Currants	..	140 ,,

Jelly Formation.

In several batches of strawberry juice that had been expressed from the fruit by the hydraulic press and allowed to complete the required fermentation in the " juice " tanks rather than in the " pulped fruit " vats, a peculiar formation of a thick layer of jelly was noted. In some cases the layer was quite 8″ deep and extended coherently over the surface of the juice. Its removal was extraordinarily difficult. Stainless steel sieves were satisfactory only for a very short time as the jelly clogged all the meshes. The supercentrifuge appeared to disperse the jelly into such a state that it passed almost completely through the bowl. In some cases large 60-gallon tubs were filled with the jelly which had been scooped off the vats and allowed to drain. If the juices were syruped and filtered before the removal of the greater part of the jelly, the filter quickly became clogged and the filtrate was reduced to an uneconomic flow. It was unfortunate that, owing to the extremely difficult conditions existing in the factory at this stage of the season's work, it was impossible to keep separate the bulks of juices from various batches of fruit and consequently the condition of the individual lots of fruits which gave the jelly effect is not known. It is probable that the jelly was of the " pectic acid " type.

Juice Clarification.

The earlier pressings of strawberry juice, where insufficient fermentation had occurred or before the enzyme treatment had been used, were invariably difficult to carry out, and the juice which was collected from the press retained much slimy tissue that had been forced through the cloths by the great pressure. This tissue greatly limited the quantity of juice obtainable before the need to repack the filter arose, and for this reason it was decided to carry out some experiments with a centrifuge as a means of preclarifying the juice. The machine used for this was a Sharples Super-centrifuge and gave an excellent performance in every way. Indeed, it may be said to have saved the situation, for prior to its use it was difficult to force more than 400—600 gallons of syrup through one setting of the filter, whereas syrups made from juices that had been centrifuged were filtered at four to six times the speed. The material left in the bowl was a mixture of yeast, pectin deposit, enzyme base (bran or pollard) and fruit tissues. In the later stages of the season's work, where pressings were more satisfactory and the cloths were retaining practically all the tissues, the material in the bowl consisted of a nearly pure yeast deposit which tasted quite characteristically of the particular fruit.

When the need for a more lengthy fermentation was appreciated, the super-centrifuge was still retained, for it delivered a juice that was almost clear. In fact, with some batches of raspberries and loganberries, the centrifuge delivered a perfectly brilliant juice and eased the syrup filtration to a remarkable degree.

Towards the end of the season, a large Alfa-Laval fruit juice clarifier was tried out. The output of 600—900 gallons an hour was an asset when the factory was working with peak loads of fruits, and clarification was also efficiently achieved by this machine.

Juice Stabilisation.

Immediately after the juice had been centrifuged, sugar was incorporated in 800-gallon enamelled, steel tanks fitted with patent vortex mixing propellors. 2 tons of sugar could be completely dissolved in 400 gallons of juice in 8 minutes in the cold. Much consideration was given to the problem of the degree of sweetness to use. The preliminary work at Long Ashton showed definitely that increased sugar concentration effected greater retention of fresh fruit flavour and less oxidative changes on keeping. It was also known that the lower sugar syrups (38%—45%) presented many difficulties in their stabilisation. On the other hand, the chief criticism of milk bar syrups was their excessive sweetness. To meet this point it was decided to keep the range for National Mark milk shake grade syrups between 50—55° Brix. Actually, strawberry was adjusted at 52—53° Brix, whilst the other fruits, on account of their higher acidities, were raised to 55° Brix. Pure cane sugar was used for this. Any hopes that may have been entertained concerning the incorporation of solid sugar into a brilliant, pulp-filtered juice to avoid the filtration of the finished syrup were doomed to disappointment. Brilliant juices were treated with sugar, but the clarity was completely spoilt and a large quantity of extraneous matter was introduced into the syrup. The actual filtration problems concerning the clarification of the syrup are dealt with in the next section.

It was well known that syrups of 50—55° Brix would ferment unless pasteurised or treated with SO_2. The latter method was, naturally, adopted in a completely cold process and for the first time the preliminary laboratory experiments were found to have given completely misleading results. In previous years, 200 parts per million of SO_2 had been sufficient to retain small bulks of syrups free from fermentation, but a similar quantity of preservative when used on large batches of strawberry syrup failed to suppress the yeasts. Strawberry was the only syrup which caused any anxiety, and a large series of experimental results indicated that with the other three more acid juices 200 parts per million provided complete freedom from fermentation.

The later history of the strawberry syrup was such that it was obvious that acidity was as important a factor in keeping quality as the chemical preservative. When various adjustments had been made in this respect with due regard to the curdling of milk, the syrups were perfectly stable and have remained so for nine months.

Several difficulties were encountered in the stabilisation process. The syrup was first treated with the requisite amount of potassium metabisulphite (K.M.S.) which had the immediate effect of bleaching the natural colour of the fruit to a much lighter shade. This was rectified by the use of a permitted colouring matter to match the original shade of the juice. It was found, however, that when the K.M.S. was added to the syrups which were revolving in the pan, considerable amounts of SO_2 were evolved and lost into the atmosphere. For example, when sufficient preservative was added to give 350 parts per million of SO_2 in the syrup, the actual figures given by Monier-William's method on the syrups 15 minutes after mixing in the SO_2 were :—

Strawberry ..	345 p.p.m.
Raspberry ..	320 p.p.m.
Loganberry ..	256 p.p.m.
Black Currant ..	214 p.p.m.

The losses were eventually overcome by the addition of a safety allowance of sulphur dioxide which varied with each fruit and by agitating the syrup for a minimum period. No significant losses of SO_2 were caused by filtration or bottling processes.

The following data show that the K.M.S. is effectively incorporated in a batch of 700 gallons of syrup very quickly after mixing :

Syrup at top of mixing vat	1 minute after addition of K.M.S. ..	SO_2 340 p.p.m.
,, ,, bottom ,,	,, 1 ,, ,, ,, ,, ,, ..	,, 353 ,,
,, ,, top ,,	,, 3 ,, ,, ,, ,, ,, ..	,, 353 ,,
,, ,, bottom ,,	,, 3 ,, ,, ,, ,, ,, ..	,, 344 ,,
,, ,, top ,,	,, 6 ,, ,, ,, ,, ,, ..	,, 350 ,,
,, ,, bottom ,,	,, 6 ,, ,, ,, ,, ,, ..	,, 350 ,,

Syrup Filtration.

The preliminary investigations at Long Ashton had indicated the superiority of the plate and frame filter for syrup filtration, and a large 30 chamber Johnson filter was used with " Hyflo " as filter aid. With strawberries, it was soon found that the syrup was filtered with greater ease than the juice itself and consequently filtration of the syrup was adopted for all the remaining bulks of products.

" Hyflo " filter aid was eventually used both for pre-coating the filter and for mixing with the syrup to be filtered. On an average 30 lb. pre-coat and 20 lb. per batch of 700 gallons of syrup were used.

One interesting fact emerged during the processing of the strawberry syrup. The syrup was circulated through the filter until the filtrate appeared to be brilliant. At this stage, the clear syrup was received in a clean collecting vat. The brilliancy, however, soon commenced to deteriorate and a milky opacity appeared in the syrup. This increased until a faint deposit settled on the bottom of the bottle. The deposit was quickly identified by chemical and microscopic means as being " Hyflo " particles which had apparently penetrated the filter cloths. An experiment was then carried out with a batch of strawberry syrup in which samples were taken at intervals after the writer had decided that the syrup was brilliant. A gallon jar sample was taken at the moment the circulation was stopped and two further samples after 300 and 1,000 gallons had been filtered. On comparing the original sample with the last sample jar of syrup it was obvious that the former was not actually brilliant relative to the latter. The sample had appeared to be clear, but it is apparent that " clarity " is a relative term and the syrup should be allowed to circulate for some further time before being collected.

A remarkable effect of increased acidity of the syrup affecting its ease of filtration was noted in the case of strawberry syrup. The fruit in question was of high quality and in first class condition. Fermentation had been rather slow, but viscosity measurements showed that pectin had been rapidly destroyed. The juice was centrifuged with ease but, on attempting to filter the finished syrup, the filter refused to pass more than 175–200 gallons per setting. The cloths were cleaned, dried and beaten until clear of filter aid, and various combinations of filter aid were used but to no avail. The filter was incapable of dealing with the syrup. However, at this precise stage, the question of the advisability of raising the acidity from flavour and other points of view was being considered and immediately this was done the filter, at one setting, passed through and filtered to a perfectly brilliant condition over 7,000 gallons of syrup. Records established that the fruit in question had been of a very sub-acid nature and that the actual acidification which effected so remarkable an improvement in filtration raised the acidity from 0.4% up to 1.1% citric acid by weight.

There is no doubt that strawberry syrup presented, in general, the greatest difficulties in filtration. With the other three fruits—each of them with a considerably higher natural acidity—satisfactory and straightforward manipulation was achieved.

Bottling.

The whole of the 50,000 gallon output was put direct into one gallon glass jars when processing was completed. The filtered syrup was pumped to a reserve tank at a high level and allowed to gravitate into a Gravfil filter capable of filling 600 gallon jars per hour. The jars were sterilised with 2% SO_2 solution immediately prior to being filled and corks which had been soaked in a similar solution were used for closing the jars. The floor and air near the bottling machine was shown by exposing plate cultures to be by no means germ-free and consequently the jars were not exposed until just prior to filling. The SO_2 was drained out before filling the jars.

CHARACTERS OF THE SYRUPS.

Stability.

No trace of fermentation in raspberry, loganberry or black currant syrups has been noted in the factory or reported from consumers. Some trouble was experienced early in the season with strawberry, but this was quickly rectified. Incubation tests at 30°C. have now been completed on every batch of syrup in stock and completely satisfactory results have been obtained. Such fermentation difficulties as have been encountered are possibly due to the high juice content of the syrups.

National Mark pure fruit juice syrups contain about 60% of juice ; this juice contains nitrogeneous materials which are assimilable by yeast cells and, if suppressive conditions are not adequate, the yeasts have available the essential nutrients to enable them to multiply in the syrup. Many commercial syrups not sold under the National Mark have been examined at Long Ashton and, despite the fact that preservatives are not used up to their permitted limit and the acidities are generally exceedingly low—some syrups being actually neutral to litmus—fermentation has been observed is only one or two cases. The juice contents of the latter products are thus suspected of being lower than that of National Mark syrups.

Some loss of clarity has occurred in nearly all the National Mark syrups. In some batches of black currant it has been but slight and the diluted syrups have remained quite clear. Many batches of black currant syrup, however, are now as brilliant as the day they were bottled. Both raspberry and loganberry have thrown slight deposits. " Hyflo " is also in evidence in the syrups from these two fruits, and the syrups have become opaque, although refiltration gives brilliant products which remain so for a considerable period. Strawberry has again been the troublesome syrup, for on small batches it has been shown that deposits were precipitated even after three filterations. The material which comes out of solution is being investigated and there is evidence that it is of a pectinous nature. The fact that strwberry is the fruit which is most liable to deposit pectin materials, whilst black currant remains practically free from deposit, may perhaps be explained by the short periods allowed for the enzyme action in the case of strawberries—on account of their already fermenting condition on arrival at the factory—and the very much longer period available in the case of the black currants.

Flavour.

It is probaly safe to claim that the commercial venture with which this Report is primarily concerned is the first of its sort in this country and probably in the world. Consequently, there were no accepted standards to work to, and each day brought fresh problems which had to be faced in the light of the knowledge gained from the preliminary small-scale experiments. The factory was established to produce fruit syrups by the cold process, because the experiments at Long Ashton had indicated the attractive nature of the syrups made in the cold when compared with those which had received heat treatment. It is pleasant to be able to report that the flavours of the earlier experimental materials were at least equalled and generally very greatly exceeded by those of all the syrups in bulk made at the Bristol factory. The strawberry syrup is considered by a large number of competent authorities to represent one of the most significant achievements of last season's processing. Although not so intense in flavour as other fruits, it is remarkable for its delicate, smooth flavour, which is absolutely true to the fruit. Raspberry and loganberry are easily distinguished from each other. This is no mean test in a syrup, as the fundamental character of the two fruits is very similar. Black currant syrup is remarkably fully flavoured and is considered by many to be the finest product in the series.

Certain observations have been made which suggest that a fermentation in the milled fruit which is allowed to become excessive alters the flavour of the syrup to a noticeable extent. The effect is not to diminish the ultimate flavour of the syrup, but to introduce a number of subsidiary tastes, due probably to aldehydic and etherial compounds formed as by-products of the fermentation process which tend to mask the true fruit character. A very interesting observation has been made in this connection. A small sample of raspberry syrup, made from some fruit which had fermented to an extreme degree, was practically indistinguishable from a normal loganberry product. The fermentation in the raspberries had evidently resulted in chemical changes in composition, bringing it more into line with that of the loganberry.

Comparisons between the National Mark syrups and other products of the " fruit juice " class are concerned largely with the trueness of flavour of the syrup. Many products have been rested whose flavours have been quite unrelated to the class of fruit appearing on the label. Again, in others, it appeared that any fruit flavour which existed in the syrup had been completely overwhelmed by synthetic flavours having, with hardly any exceptions, little real resemblance to the true fruit character. Some were definitely unpleasant. Syrups made from concentrated fruit juices carried a definite taste of " cooked " fruit which compared unfavourably with the fresh fruit flavour of the National Mark syrups. Several syrups have been encountered in which very high sugar concentrations have been used for the purpose of extreme safety against fermentation. These products naturally retain the fruit flavour to a considerable extent, except where concentrates have been used as a base, but when the sweetness has been diluted to the necessary degree, the flavour of the fruit has become extremely weak.

The writer, in his capacity as Research Officer in Fruit Products at Long Ashton, has naturally been in touch with many manufacturers of syrups and essences. A great deal of work has been done in the laboratory at Long Ashton and there does not appear to be any immediate prospect of economically improving the National Mark syrups either by the addition of pure fruit or synthetic essences.

Retention of flavour has been satisfactory. The syrups have been stored under humid conditions but at a fairly steady temperature, and most of the jars in stock have been kept in darkness. Very stringent tests have so far failed to discover any appreciable changes in flavour.

National Mark Scheme.

The whole output of the Factory was examined, analysed and tasted for the purpose of allowing the syrups to be sold under the National Mark. All the syrups were accepted. It is part of the scheme that all syrups sold under the Mark should be tested with regard to curdling. Using a dilution of $\frac{3}{4}$ fluid ounce of syrup plus 7 fluid ounces of milk at 40°F., no curdling occurred with any syrup over a very protracted period. Moreover, the concentration of syrup could be definitely increased without any visible curdling.

Hot milk shakes have been satisfactorily made at a large number of bars throughout the country without any trouble arising. In a few cases, however, difficulties have been experienced with curdling, but the elucidation of the precise mechanism of curdling with the two buffer systems of milk and fruit syrup present is by no means a straightforward problem.

Mineral Water Grade.

During the 1936 season, some syrups were acidified to 1.5% citric acid by weight and these were then mixed with soda water for beverages. The very remarkable retention of true fruit character was significant, and so encouraging were the results that a great deal of work was then carried out with the idea of making a mineral water grade syrup. The experimental work was instrumental in attracting the interest of the National Association of Mineral Water Manufacturers who were searching for some beverage with a fresh appeal which could be distributed nationally under fixed and controlled trade terms. It is hoped that during 1937 a National Mark scheme for aerated fruit juices will be established and the quality of the products controlled by the Ministry of Agriculture, whilst the selling conditions will be regulated by the Trade Association. National distribution actually did commence in January, 1937, without awaiting the introduction of a National Mark scheme, and by March over 200 manufacturers had commenced regular bottling.

THE EFFECTS OF THE REMOVAL AND RETENTION OF LATERAL BRANCHES IN THE PRODUCTION OF SETS OF THE CRICKET BAT WILLOW.

By **H. P. HUTCHINSON.**

The problem, which primarily concerns rate of growth, the formation of " Cross-grain " and development of " Stain " in the timber, (1) was investigated in the following way :

Fourteen established stools of Bat Willow growing in a continuous row were taken. They were three years old and had yielded a crop of rods which had been removed the previous autumn. Numerous shoots started growth in April. A reduction to 4 and 5 per head was made in early May, and a further reduction to one shoot per stool was made in June. At this time the shoots were about 9 inches long and uniform in size. As growth proceeded during the remainder of the summer the shoots on the stocks Nos. 1, 3, 5, 7, 9, 11 were deprived of their axillary shoots as soon as they appeared, the subtending leaves being allowed to remain.

The shoots on stocks Nos. 2, 4, 6, 8, 10, 12 were allowed to grow without interference except in two cases when one of the two leading shoots which developed was removed. At the time of leaf fall, i.e. at the end of October, the leaves on the no-lateral rods contrasted markedly with the leaves from the rods bearing laterals, in being persistent, much larger and of a green colour.

The rods were cut in early November and were investigated as follows :—

Series A. Laterals removed.

Measured, weighed, leaves counted and weighed.

Series B. Laterals present.

Main stem measured and weighed.
Lateral branches weighed.
Leaves counted and weighed.

The leaf data were obtained by counting and weighing the leaves remaining on the plants at the time when the rods were cut, counting the number of nodes present, whereby the total number of leaves formed during the year was ascertained, and hence calculating the weight of these leaves by proportion, the nodes being taken as denoting the number of leaves formed during the year. For example :—

Plant No. 2. Number of leaves present on Nov. 6. 634
,, ,, nodes ,, ,, ,, = 1002
i.e. ,, ,, leaves formed during year = 1002
Weight of 634 leaves = 82.5 grams.
,, ,, 1002 ,, = 130.3 ,,

SERIES A. LATERALS REMOVED.

Rod No.	*Length of Rod.*	*Weight of Rod.*	*Total No. of Leaves.*	*Weight of Leaves.*	*Weight Ratios: Leaves to Rods.*
	inches.	*grams.*		*grams.*	
1	91	70.3	68	20.34	1 : 3.48
3	81½	65.0	73	15.6	1 : 4.17
5	79¼	67.4	53	10.2	1 : 6.6
7	85¼	130.6	176	22.3	1 : 5.8
9	66	56.8	54	10.3	1 : 5.5
11	69¼	54.1	61	12.0	1 : 4.5
13	83½	71.2	126	13.6	1 : 5.2
	555	515.4	611	104.3	
Average	79.4	73.6		14.9	1 : 4.94

SERIES B. LATERALS PRESENT.

Rod No.	*Length of Stem.*	*Weight of Stem.*	*Weight of Laterals.*	*Total No. Leaves.*	*Weight of Leaves.*	*Weight Ratios: Leaves to Rod.*
	inches.	*grams.*	*grams.*		*grams.*	
2	102	212.8	115.2	1002	130.3	1 : 2.51
4	89½	164.8	79.7	790	98.6	1 : 2.48
6	108	259.8	169.5	975	95.3	1 : 4.5
8	103½	249.5	273	1411	156.6	1 : 3.3
10	98	187.5	70.5	888	95.9	1 : 2.69
12	104	292.2	78.8	737	101.0	1 : 3.6
	605	1366.6	786.7	5803	677.7	
Average	101	227.7	131.1		112.9	1 : 3.18

Discussion.

Length of Rod.

Individually, except in one case, the rods without laterals did not attain the length of the rods with laterals. The mean figures—79.4 and 101—are significantly different as proved by statistical methods of analysis, the odds being greater than 1 in 100. The length in Series A is sufficient to justify the anticipation of rods being long enough for planting out purposes at the end of the second year, but they would be too slender for this purpose, as judged by the girth measurements which were taken, but are not included.

Weight of Rod.

The figures in the two cases bring out the difference more strikingly than in the case of the lengths. Individually, in all cases, the differences in weights are decided and ratio of the means greater than 3:1.

The mean figures give a probability figure greater than 0.01, i.e. the chances that the two means would be the same are less than 1 in 100.

The results for weight of rod justify the conclusion that at the end of the second year the rods in Series A would not be big enough to plant out.

Effects on Growth.

The rods from which the laterals had been removed during the summer were thus smaller in length and weight than rods on which the laterals had been allowed to grow freely, the differences in the two cases being respectively in the ratios of 79:101 and 74:228, and by contrast would require one or two years longer in the nursery before attaining a stoutness sufficient to support a head of branches.

Ratio of Weight of Leaves to Weight of Stem Substance.

The greater amount of stem substance formed when laterals are present is associated with the greater number and greater weight of leaves present, but the stem increase is not proportional since the mean in the no-lateral series is 1 part leaf to 4.94 parts stem substance and in lateral series the corresponding figures are 1 to 3.18.

Statistical investigation of these figures proves their accuracy in 98 to 99 cases in 100.

Effects on " Cross Grain " and " Stain."

The non-lateral rods having no scars and being completely bark covered should produce timber free from " Cross-grain " and " Stain." In the case of the rods with laterals, the latter would need to be removed by close cutting before planting out in permanent places. The wounds so made would create conditions favourable to the development of " Cross-grain " and " Stain."

Conclusion.

The definite character of the data in showing advantages and disadvantages attending the two methods of treatment in the raising of sets suggests that the best results might be obtained by compromising between the two systems. With this end in view further experimental work would involve partial reduction of shoots either (1) by cutting a number out completely, (2) by disbudding a number early in the year, or (3) by cutting back the laterals in the summer, leaving a sufficient length for secondary laterals to develop from them.

REFERENCE.

(1) Hutchinson, H. P. " Defects in Cricket Bat Willow Timber." *Ann. Rept. Long Ashton Res. Sta.*, pp. 180–185, 1933.

DORMANT ROOTS AND BUDS OF THE CRICKET BAT WILLOW—*SALIX CAERULEA*—AND THEIR EFFECTS ON THE WOOD.*

By H. P. HUTCHINSON.

The groups of small knots present in willow timber, known in the willow industry as "Grape" or "Flower of Willow," are due to the presence of root initials and young buds embedded in the phloem of the tree.

In transverse or oblique sections, as on the edges or the back of a cricket bat, they appear as small groups circular or oval in outline according to the direction of the plane of the cut: in longitudinal section, as on the front face of the bat, they form lines which cross the annual rings of the wood at right angles. The curvature or cross grain in the wood which these structures cause may be explained by observing their development during the period of growth of the tree.

Root Initials.

These consist of masses of closely packed, thin-walled cells, lying in close contact with, and external, to the cambium. They are most numerous near nodes and are present throughout the aerial parts of the tree.

Well marked cases have been observed in current year's wood at the base of the third leaf at a distance of about half an inch below the growing point.

Root initials were noted by Trécul (see 1) in 1846 who called them "bourgeons des racines." Borthwick (see 1) pointed out their association with outward swellings on the bark. Gravenitz (see 1) noted that adventitious roots arose from preformed initials which were opposite the ends of wide medullary rays.

Root initials are persistent structures, capable of living as undifferentiated masses of cells throughout the lifetime of the tree.

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*Paper read before the Forestry Section of the British Association, Blackpool, 1936.

They have been found in boles of willows 25 to 30 years old, lying in the same position relative to neighbouring tissues as in the one year old shoot.

During the period of growth of the tree the single root initial divides into several separate masses, the multiplication increasing with age. Twenty such root initials have been noted existing as a colony in a bole about 20 years old. The space occupied by the colonies varies ; it may amount to two square inches of surface. Under suitable conditions at any period in the life of the tree the cells of these colonies of root initials elongate, differentiating as they grow outwards and bursting the bark to form a root system.

Effects on the Wood. A median section horizontal or longitudinal through a root initial in a stem shows the margin of the wood as a pointed elongated projection, the cambium lying between the two tissues. Thus curvature occurs due to the arrangement of the wood elements.

The projections are solitary (single) in the case of young stems because the initial roots do not appear to multiply in number until the brown bark is formed, which occurs generally about the fifth year in the life of the tree. The increase in the number of wood projections indicates the increase in the number of root initials formed.

In a large tree the following structure may be observed.

(1). Colonies of pointed conical projections (called " pins " by willow merchants) on the outside surface of the wood. Each point indicates the position of a root initial in the phloem, the number of pins in a colony denoting the number of root initials present.

(2). In a longitudinal section of the stem the presence of wavy grain or knots or " Grape " the amount of which depends on the number of root initials in the colony.

Bud Knots.

In longitudinal section of a one-year-old shoot passing radially through a bud the internal arrangement of the tissues may be observed.

(1). Cells of tracheidal character arranged as a strand or trace passing in an oblique downward direction from the base of the bud through the cortex and wood and ending on the outer margin of one of the re-entrant angles in the pith border.

(2) The trace of the subtending leaf of the bud can be similarly followed to the same angle.

In order to admit of the passage of these two traces the wood elements are arranged round them so forming local wood curvature. The upper wave due to the bud trace is greater than the lower wave due to the leaf trace; the latter fades out in the succeeding year.

Through subsequent years the bud maintains its position just within the bark by the growth of tissue at its base which forms a kind of stalk. This stalk or trace becomes embraced by the new wood, whereby curvature of grain results as may be seen in longitudinal section. The crest of the wave in the wood is directed outwards and, as in the case of the wave due to root initials, is projected as pointed cones at the margin of the wood. The trace tissue within the wood dies and turns brown, thus serving as a ready means of distinguishing bud and root knots since the latter consist of solid wood throughout, no dead core being present.

More Complicated Cases.

Case I. Where the Bud grows out to become a Shoot. A daughter bud develops as a lateral on each side of the trace in the region of the phloem. If the shoot be persistent these lateral buds become separated as a result of increase in the thickness of shoot and main stem. Their attachments to the shoot and not to the main stem may be traced by sectional exposures. These buds may remain dormant or may develop into shoots having similar lateral daughter buds.

Case II. Where the Bud grows out as a Shoot which dies. This occurrence is usual. Lateral buds in this case develop more strongly. As they are forced wider and wider apart, due to thickening of the bole, they develop lateral daughter buds which similarly become separated. Ultimately a colony of dormant buds is formed always at the original nodes of the stem. The strongest of these buds develop traces which at any later period in the life of the tree can be traced to their positions of origin, and their ages so revealed.

The bud colony area may occupy two square inches of stem or more. The pin-like wood projections seen on removing the bark indicate their presence with the accompanying cross grain tissue in the underlying wood.

Frequently root and bud knots are mixed in the same colony as should be expected.

In carrying out this work the following facts have been brought into prominence.

Dormant Buds in the willow seem to arise from the existing bud tissue only and not from other tissues. The term "adventitious" when applied to them should be understood in this sense.

Dormant Roots similarly arise from pre-existing primitive root tissue but they may be induced to form from a callus in *S. caprea*, *S. alba* and probably in other species.

REFERENCE.

(1). Lek, H. A. A. van der. "Anatomical Structure of Woody Plants in Relation to Vegetative Propagation. *Report and Proceedings of the IX International Horticultural Congress, London*, pp. 66-76, 1930.

PLATE I.

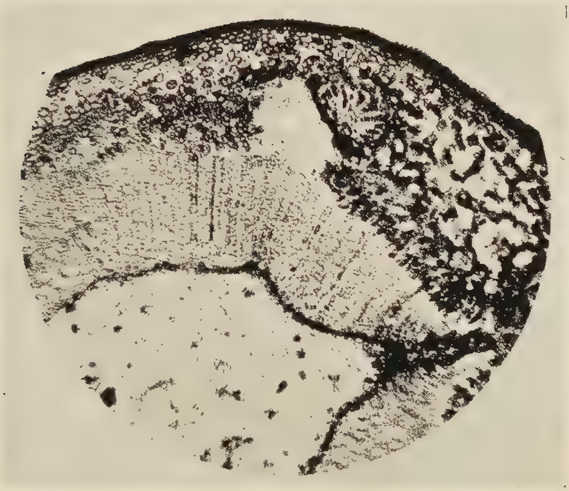


FIG. 1.

Transverse section through one year old stem showing Root Initial at A.

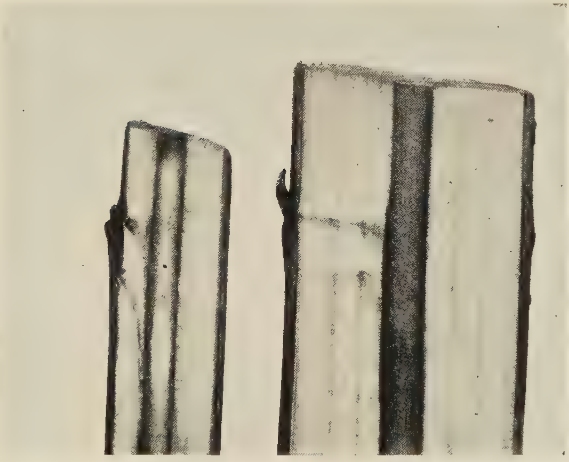
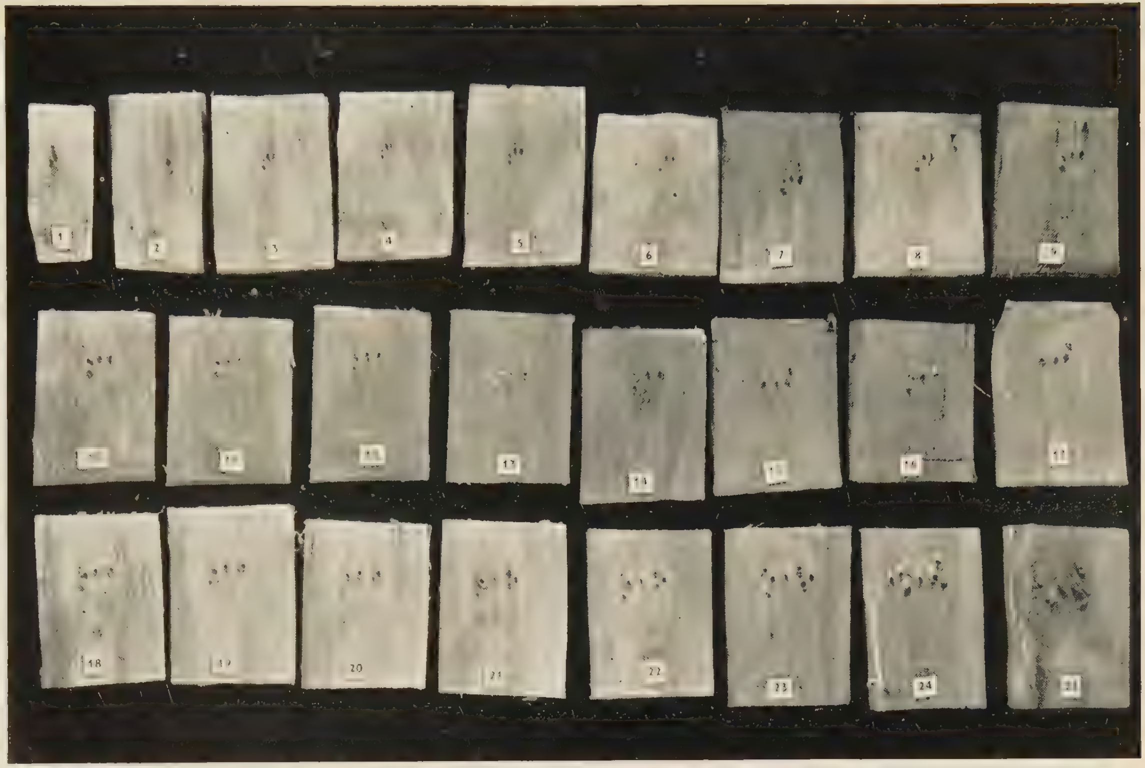


FIG. 2.

Longitudinal sections through one year old and three year old shoots showing Bud and Leaf Traces.

PLATE III


1
2
3
4
5
6
7
8
17
18
20
21
22
23
24

Longitudinal Sections through wood showing increase in number of Dormant Buds from the first to the twenty-fifth year

The present summary reports the salient points in connection with the work in the Vale of Evesham.

The investigations in the Evesham Vale have been carried out over the period 1926-1934, the time being necessarily rather prolonged owing to changes which have occurred in methods of soil surveying and to the fact that the pomological observations were made by members of the Station staff as opportunities occurred during the course of their normal duties.

The investigations carried out in this survey, both on soils and fruit, have been of a much more detailed character than those made in the previous surveys of the Old Red Sandstone areas.*

On the soil side this has been possible because or recent developments in methods of soil surveying, the old method of textural classification having been abandoned for the modern profile method in which soils are classified as Series and Types and mapped as such.† In the present case it was found possible by the use of this method to classify the soils of the whole area surveyed into Series and Types and to map the distribution of these on a scale of 6″ to 1 mile. These detailed maps, whilst on too large a scale for publication, have been filed at Long Ashton for advisory purposes and for reference by growers and others, if desired, whilst it is hoped to publish a map for popular usage on a 1″ to 1 mile scale.

In addition to the soil maps a collection of soil monoliths illustrating the characters of the main soil profiles has been made. These are preserved specimens of actual soil sections which are taken into special containers in the field in such a manner as to preserve the main characters of the profile. They can be kept indefinitely as museum specimens for reference purposes. (See Plate I).

On the pomological side, attention has been given to the history of the fruit and market garden industries and their present conditions and problems; to the detailed behaviour of the various classes and varieties of fruits grown in the area, their distribution and relationships to soil conditions; and to questions of fruit quality, and the incidence of pests and diseases and their control.

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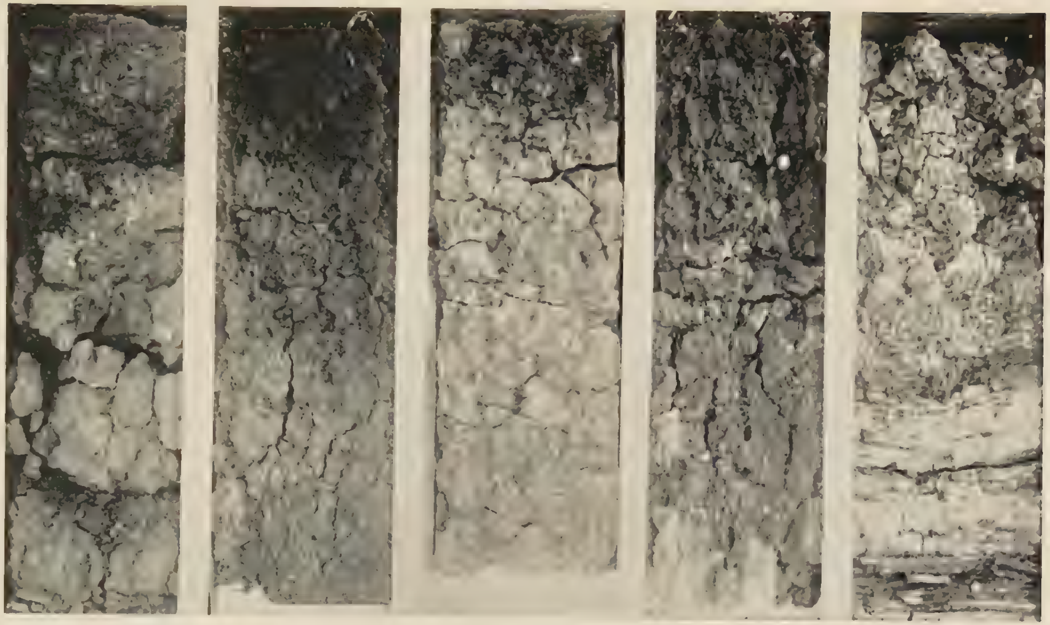
* See Ministry of Agriculture and Fisheries Bulletin, No. 15 (1931), for a full account of the Old Red Sandstone areas.

† A soil profile is a soil section from the surface down to the unweathered rock. Soils in any given Series have similar profiles. Types are sub-divisions of Series on the basis of textural features of the surface soils. For details of the profile method of survey adopted for Great B itain see First Report of Soils Correlation Committee, published by the Ministry of Agriculture and Fisheries and Department of Agriculture for Scotland, December 7, 1931.

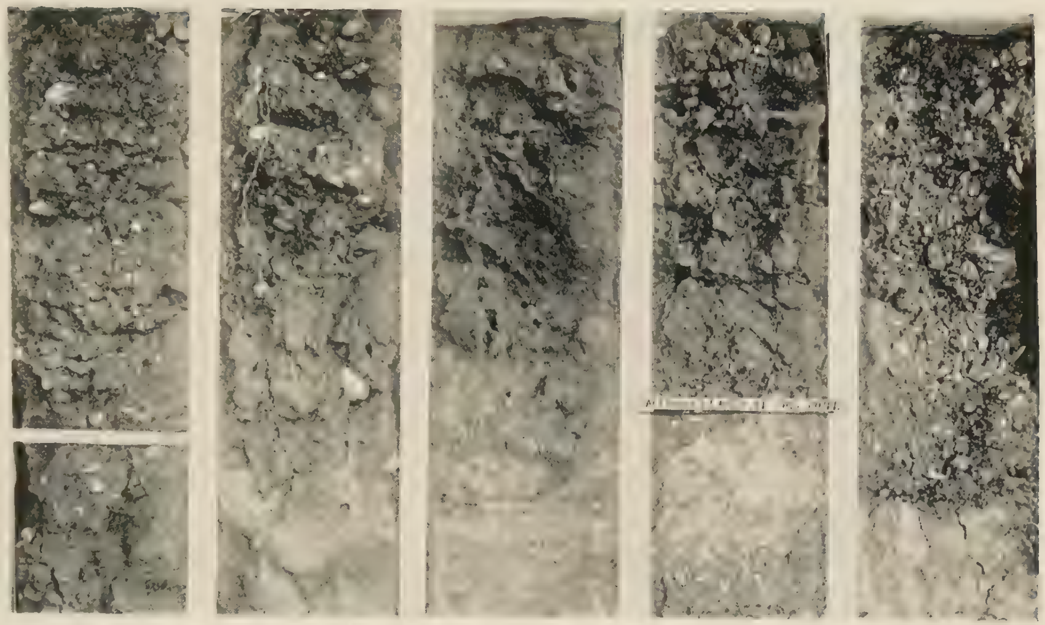
Plate I. Monoliths of Soil Profiles occurring in the Vale of Evesham.

Fig. 1



Worcester Clay, Honeybourne Clay, Charlton Bank Clay, Evesham Clay, Haselor Clay.

PLATE I Fig 2.



Cropthorne Heath Heavy Sand, Dunnington Heath Heavy Sand, Cheltenham Light Sand, Badsey Heavy Loam, Longdon Hill Clay.

The main growth problems have been specially investigated and classified, and field experiments made to throw light on problems such as die-back in plums and manuring of various fruits in cases of failures.

Photographic records have been obtained of typical trees on all the important soil types, which serve to illustrate the various types of trees which may be expected to develop on the different soils. (See Plate II).

At the beginning of the survey special work on vegetable crops was not contemplated, but this became possible during the period due to the appointment of a special officer at Long Ashton for the purpose of investigating vegetable diseases in the Evesham area, who in addition to obtaining much information on diseases was able to make a study of the wider aspects of vegetable culture.

In the special investigations on vegetable crops for the purposes of the survey, particular attention has been given to the relationships of soil to the successful growing of various crops and to the incidence of special diseases.

A full report on the survey has been submitted to the Ministry of Agriculture and Fisheries and it is hoped that the Ministry will shortly publish a popular account of the work in bulletin form which will be available to the general public.

The following notes summarise the main features of the extent, physiography, climate, geology and soils, and of fruit and vegetable culture of the surveyed area, and list the main conclusions reached relating to soils, fruit and relationships between soils and fruit, and to vegetable culture in relation to soil conditions.

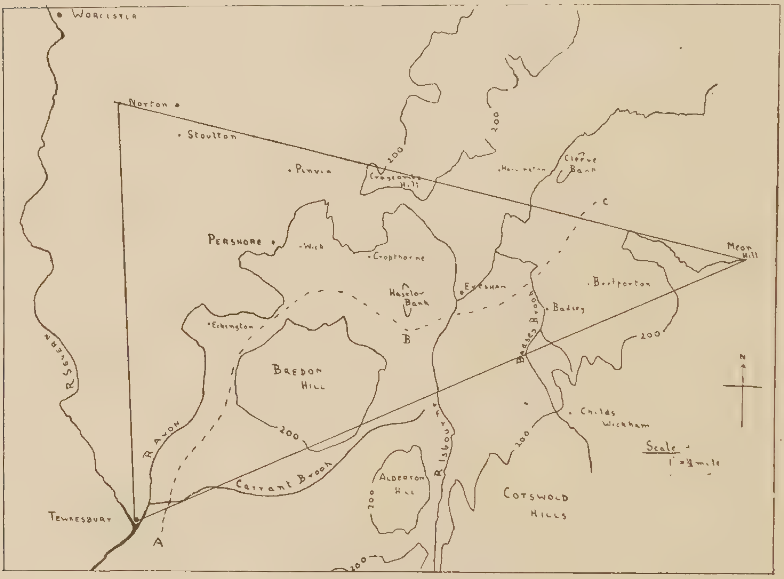
GENERAL DESCRIPTION OF THE VALE OF EVESHAM AREA.

Extent.

The area surveyed comprises approximately 150 square miles, situated in the Vale of Evesham, and includes the two important fruit growing and market gardening districts around the towns of Evesham and Pershore.

About two-thirds of the area lies within the triangle shown in the accompanying sketch map. The apex of the triangle is at Norton, north of Tewkesbury, and the base is formed by a line joining the latter town with Meon Hill to the north-east of it.

The line marked A, B, C on the sketch divides the area into "north-western" and "south-eastern" sections in a convenient way for discussion of the superficial geology of the area.


Worcester
Norton
Stoulton
Pinvin
200
200
Craycombe Hill
Harvington
Cleeve Bank
C
Meon Hill
Pershore
Wick
Cropthorne
Haselor Bank
Evesham
Bretforton
Badsey
Badsey Brook
Eckington
B
200
N
R. Severn
Bredon Hill
200
R. Avon
Childs Wickham
200
Scale
Carrant Brook
Alderton Hill
200
R. Isbourne
Cotswold Hills
Tewkesbury
A
200

Sketch Map of the Evesham area.

Physiography and Climate.

The area as a whole consists of a large, low-lying plain, rarely above 150′ O.D., and is flanked on the east by the Cotswold Hills.

The continuity of the plain is broken by occasional low rolling hills, rising to about 200 ft. O.D., and more prominent heights, such as Bredon Hill (961′ O.D.) and Alderton Hill (674′ O.D.), both outliers of the Cotswolds, and Craycombe Hill, which forms the termination of a ridge running in a north to south direction and abutting into the north of the area. The river Avon, which flows westwards from Evesham to Pershore and then runs in a south-westerly direction towards Tewkesbury, intersects the area and forms the main drainage system.

The north-western section, through which the Avon runs, contains the two important towns of the area, Evesham and Pershore, together with several villages, Wick, Cropthorne, Fladbury and Charlton in the Avon valley, and Eckington, Bredons Norton, Kemerton and Conderton around the slopes of Bredon Hill.

The south-eastern section is drained by the river Isbourne and the Carrant, Badsey and Broadway brooks, all of which flow into the Avon. Tewkesbury is the only town of importance, whilst the main villages are Badsey, Bretforton and Childs Wickham.

The climate is characterised by mild winters, mean maximum day air temperature for January being 43-44° F., and by summers of only moderately high temperatures, mean maximum day temperature for July being 71° F. Rainfall is fairly evenly distributed over the year, the annual average for the period 1881–1915 being 32″.

Geology.

Solid Geology. The Geological Map (Solid Edition of 1886) shows the lower lying land of the area to be occupied almost entirely by the Lower Lias formation, which occurs in the district as a strip running roughly from north-east to south-west between the Oolite formation of the Cotswold Hills and the Triassic rocks of the plain of Worcester.

Bredon Hill and Alderton Hill are outliers of the Oolite formation, and a narrow tongue of Keuper Marl is shown as composing a strip of land to the west and north-west of Evesham. The Keuper outcrop may be seen in the shallow valley on the west side of Bishampton Bank and Haselor Bank, in the southern face of Craycombe Hill and at Harvington, whilst it also forms the western face of Cleeve Hill.

The Lower Lias rocks of the area consist of thin bands of limestone bedded in blue, calcareous clays with occasional beds of blue shale. The limestone occurs mainly in the basal beds which are more usually found near the western boundary of the outcrop owing to the slight dip of the rocks towards the east. The upper beds generally consist of heavy, blue calcareous clays and, in the east, where the formation is thicker, the beds of clay may be of considerable depth and limestone bands are scarce or are only poorly developed and thin.

Superficial Deposits. The entire area has been affected by superficial deposits, glacial and otherwise, and although in some localities subsequent erosion has taken place, exposing the solid rocks, it is unusual to find any land which is entirely free from traces of surface drifts. Even where obvious indications of these deposits are lacking from the surface, the soil of the exposed Lower Lias clay contains a proportion of coarse quartz sand, indicating admixture with Triassic material.

The superficial deposits of the north-western and south-eastern sections present marked differences, as the drifts in the former section have been derived from the formations lying to the north of the area, and are mainly of Triassic origin—chiefly from Bunter Pebble Beds. On the other hand, those in the south-eastern section have been chiefly derived from formations to the north-east of the area, and consist of a variety of materials, mostly of Oolitic, Liassic, and Triassic origin, but Chalky drifts are also represented.

The area surveyed thus appears to have been the meeting place of two distinct glacial drifts coming from northerly and north-easterly directions respectively.

The extents to which the solid formations and the surface " drift " deposits affect the occurrence of soils in the area will be clear from Table I, in which the geological origins of the " parent materials " of the soils (*i.e.* the characters of the rocks and deposits from which the soils are derived) are given.

Soils.

The main features of the classification of the soils of the area are summarised in Table I. In this table it is shown that 19 Soil Series, which give rise to 32 Textural Types, have been recognised. The table also shows for each series the geological origin of the rocks or deposits from which the soils have been formed and the nature of these (*i.e.* whether clays, sandstones, calcareous, etc.). An idea of the extent and location of the various series in the area can be best obtained by studying the soil maps, and since these should be available in the future, no attempt to portray these is made in this present account. It may be stated, however, that by far the most extensive of the series in the area are Evesham, Pershore, Badsey, Haselor and Honeybourne. The relative importance of the series for fruit growing and market gardening will be evident from the section setting out the main conclusions.

Fruit.

The important practical aspects of the investigations relating to fruit are given in some detail in the conclusions section, which account must suffice for the present summary.

TABLE I.

Soil Series and Types Occurring in the Vale of Evesham.

Showing the Relationships between Soil Series, Types and Parent Materials.

Soil Series.	Soil Types.	Geological Origin of the Parent Materials.	Nature of the Parent Materials.
A. Soils derived from Solid Formations.			
1. Evesham	Evesham Heavy Loam.	Mainly Lower Lias Clay.	Grey clay, calcareous
	Evesham Clay.	,, ,, ,, ,,	,, ,, ,,
2. Haselor	Haselor Clay.	Mainly Lower Lias Clay with limestone bands.	Grey clay, calcareous, with limestone bands.
3. Chadbury	Chadbury Clay.	Mainly colluvial Lower Lias Clay.	Grey clay, calcareous.
4. Charlton Bank ..	Charlton Bank Clay.	Lower Lias Clay (with or without shale).	Grey clay, calcareous (with or without shale).
5. Worcester	Worcester Heavy Loam.	Mainly Keuper Marl.	Red marl, calcareous.
6. Worcester (Shallow phase).	Worcester (Shallow phase) Heavy Loam.	,, ,, ,,	,, ,, ,,
7. Worcester (Wet phase)	Worcester (Wet phase) Heavy Loam.	,, ,, ,,	,, ,, ,,
B. Soils derived from Superficial Deposits.			
8. Cheltenham ..	Cheltenham Light Sand.	Reworked Cheltenham Sand.	Yellow sand with calcareous gravel.
9. Longdon Hill ..	Longdon Hill Heavy Loam.	Calcareous Boulder Clay.	Grey clay, calcareous, with chalky gravel.
	Longdon Hill Clay.	,, ,, ,,	Do.
10. Hipton Hill ..	Hipton Hill Heavy Loam.	Boulder Clay mainly of Keuper Marl origin.	Red marl, calcareous.
	Hipton Hill Clay.	Do.	,, ,, ,,
11. Cropthorne Heath ..	Cropthorne Heath Light Sand	Glacial Drift or River Terrace—mainly from Bunter Pebble Beds	Pebbly red sand.
	Cropthorne Heath Heavy Sand	Do.	,, ,, ,,
	Cropthorne Heath Light Loam.	Do.	,, ,, ,,

TABLE I—*continued.*

SOIL SERIES AND TYPES OCCURRING IN THE VALE OF EVESHAM.

Showing the Relationships between Soil Series, Types and Parent Materials.

Soil Series.	Soil Types.	Geological Origin of the Parent Materials.	Nature of the Parent Materials.
B. Soils derived from Superficial Deposits.—continued.			
12. Pershore	Pershore Light Sand.	Glacial Drift or River Terrace—mainly Bunter origin.	Pebbly red sand.
	,, Heavy ,,	Do.	,, ,, ,,
	,, Light Loam.	River Terrace—mainly Bunter origin, slightly modified by sludge.	,, ,, ,,
	,, Heavy ,,	River Terrace—mainly Bunter origin—modified by sludge.	,, ,, ,,
13. Dunnington Heath..	Dunnington Heath Heavy Sand.	Glacial Drift or River Terrace—mainly Bunter origin.	Pebbly red sand.
	Dunnington Heath Light Loam.	Do.	Do.
14. Badsey	Badsey Light Loam.	Brick Earth overlying River Gravel, mainly of Oolitic origin.	Silt clay over calcareous gravel.
	,, Heavy ,,	Snow Sludge overlying River Gravel, mainly of Oolitic origin.	Do.
	,, Clay.	Do.	Do.
15. Shallow Honeybourne	Shallow Honeybourne Heavy Loam.	Snow Sludge overlying Lower Lias Clay.	Silt clay over grey clay, calcareous
	Shallow Honeybourne Clay.	Do.	Do.
16. Honeybourne ..	Honeybourne Light Loam.	Deep snow-sludge.	Silt clay.
	Honeybourne Heavy Loam.	,, ,,	,, ,,
17. Wyre	Wyre Clay.	Alluvium, mainly Lower Lias Clay and Keuper Marl.	Grey clay, non-calcareous.
18. Fladbury	Fladbury Clay.	Do.	Do.
19. Under Badsey ..	Under Badsey Clay.	Do.	Grey clay, calcareous.

CONCLUSIONS FROM THE SURVEY RELATIVE TO SOILS, FRUIT AND THE RELATIONSHIPS OF SOILS TO FRUIT GROWING.

The following conclusions of general interest and of economic importance, relating to soils, fruit and relationships between soil groups and various classes of fruit in the Evesham–Pershore area, are drawn from the data obtained in the course of the survey.

I. Soils.

The soils may be classified on the basis of soil profile characters into 19 Series, comprising 32 Types.

Soil series and geological parent materials are generally closely correlated, but a number of series may be formed from a given parent material.

The series most widely utilised for fruit growing and market gardening in the surveyed area at the present time are as follows :—Evesham, Pershore, Badsey and Haselor.

Fruit and market garden crops also occur on the following series :—Chadbury, Charlton Bank, Worcester, Shallow Worcester, Cropthorne Heath, Dunnington Heath, Honeybourne, Under Badsey, Longdon Hill and Hipton Hill.

II. Fruit.

Fruit growing in the area is very closely associated with vegetable growing and this association exercises profound influences on fruit growing practices, which in turn greatly affect the nature of the fruits grown, the growth and fruiting characters of the various fruit plants, and the measure of success achieved with different classes and varieties of fruits.

Plums.

Plums are by far the most important fruit crop, but considerable quantities of apples, black currants, red currants, gooseberries and strawberries are grown, together with smaller amounts of pears, raspberries, loganberries and blackberries.

Among plums, the varieties Pershore Egg, Purple Pershore, Victoria, Czar and Rivers' Early Prolific comprise about two-thirds of the total plantings, other varieties frequently grown being Belle de Louvain, Monarch, Burbank's Giant Prune, Evesham Wonder, Pond's Seedling, Warwickshire Drooper, Damascene and Damsons.

The main rootstocks employed for plums are Pershore Egg and Myrobolan, others being Warwickshire Drooper, Common Plum and Mussel.

Varieties and rootstocks are of importance in determining the size of plum trees in the area.

The main pests and diseases of plum are aphis, red spider, sawfly (of recent occurrence), silver leaf and die-backs.

Plums appear to be the most suitable fruit crop to combine with market garden activities.

Apples.

Apples are of much less importance than plums. Growth and cropping are not generally satisfactory where apples are combined with market gardening.

The varieties grown are mainly culinary and not well suited to modern market requirements, Lord Grosvenor, Grenadier, Early Victoria and Lord Derby comprising about two-thirds of the total trees. Bramley's Seedling, Lane's Prince Albert, Newton Wonder and Worcester Pearmain are also grown in fair quantity. High quality dessert varieties occur on a very small scale in newer plantations.

Rootstocks are mainly seedlings and where Paradise stocks occur they are invariably mixed.

Large differences in tree size due to varieties occur, but variations due to rootstock effect are not marked.

Management systems are responsible for large differences in tree size.

The main pests and diseases are caterpillars, aphis, capsid bug, sawfly (of late years) and scab. Pest and disease control is inefficient except in a few plantations where apple culture is a speciality.

Pears.

Pears, especially vintage varieties, were formerly widely planted, but modern plantings are scarce. Newer plantations contain Conference, Williams, Fertility, Comice, Durondeau, Clapp's Favourite, Beurre Hardi, Dr. Jules Guyot and Jargonelle.

Pear scab and pear midge have been serious troubles. Canker also occurs on Fertility.

Pear scab can now be controlled satisfactorily and where this is done certain sites appear suited to pear culture.

Cherries.

Sweet cherries are not an important crop and success in their cultivation is greatly dependent on soil conditions and suitable manuring.

Among the main varieties are Early Rivers, Governor Wood, Black Heart, Black Tartarian, Waterloo and Napoleon. Rootstocks are usually wildings.

The major pests and diseases are aphis and gumming, the former of which can be adequately controlled.

Soft Fruits.

Soft fruits, though of minor importance in the area to plums and vegetables, cover a considerable acreage. Production has been stimulated of recent years by canning enterprises.

Black Currants. Black currants are widely grown in small areas. The main variety is Baldwin, but Seabrook's Black and Boskoop are also of importance. Production is seriously affected by faulty pruning, "reversion," capsid and big bud, whilst leaf spot due to *Pseudopeziza Ribis* is often severe on the variety Baldwin. Disease control is frequently imperfect.

Red Currants. Red Currants are of small importance, and are grown in small areas. The main varieties are Raby Castle, Fay's Prolific, New Red Dutch and Scotch. Plantings are very mixed, capsid damage is serious and production is often only moderate.

Gooseberries. Gooseberry culture appears of uncertain value owing to the decreased requirements of the jam industry. The main varieties are Keepsake, Whinham's Industry and Careless.

The first is the most reliable sort, whilst Careless is greatly affected by soils and requires high cultural and manurial conditions.

The main pathological troubles, American gooseberry mildew and sawfly, are both well controlled.

Strawberries. Strawberry growing has been problematic during recent years and previously popular varieties such as Paxton and Stirling Castle cannot be grown successfully.

Royal Sovereign, Oberschlesien, Tardive de Leopold and Huxley are the main varieties cultivated.

Diseases are prevalent and often cause drastic failures. They include aphis, Tarsonemid mite, the virus diseases "yellow edge" and "crinkle," leaf spots, "red plant" and some red spider and occasional root rots.

Granted freedom from disease, the area appears well suited for strawberry culture.

Raspberries. Raspberry growing has been revived by canning. Lloyd George is the only widely planted sort and only succeeds on the lighter soils.

Mosaic diseases are often serious. Raspberry beetle is efficiently controlled.

Blackberries and Loganberries. These have been recently planted to supply canning factories. Growth is usually successful but mosaic diseases require attention. Raspberry beetle is well controlled.

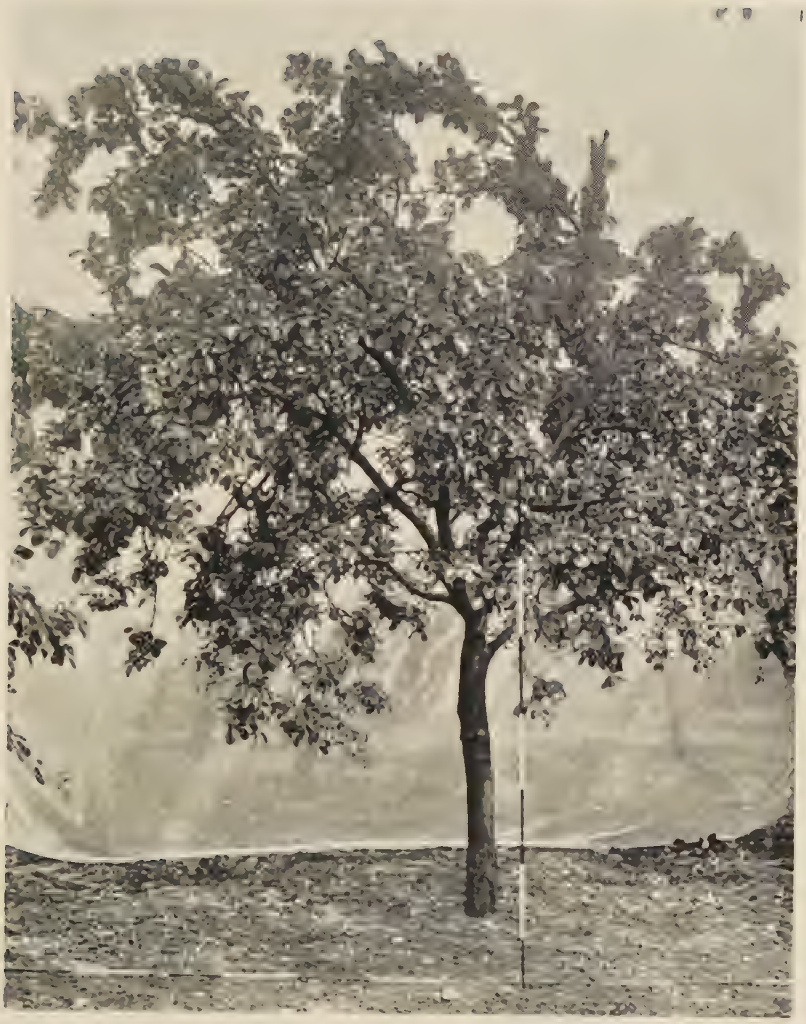
Spraying Machinery.

Spraying machinery throughout the area is usually old and unfitted for modern requirements, and production and quality of various fruits generally suffer because of inadequate and inefficient spraying.

III. Soil Series and Types in Relation to Fruit Growing.

Soil conditions in the area are of fundamental importance to the fruit growing industry. They largely determine the characteristic growth and cropping features of the various fruit plants. The relationships between soil series and types on the one hand and the behaviour of classes and varieties of fruit on the other are well

PLATE II. Fig. 1.



Typical Pershore Yellow Egg Plum growing on Evesham Clay.
Note the excellent growth.

marked and provide a useful basis for considering fruit-growing projects.

The more important relationships in connection with the main series may be summarised as follows :—

Evesham Series.

Both the heavy loam and clay types are well suited for the vigorous growth of most varieties of plums, culinary apples (Lane's Prince Albert appears to be an exception), pears and most soft fruits (raspberries an exception). Cherries are not successful.

The quality of plums is especially excellent. Problems which arise are lime-induced chlorosis, occasional waterlogging, especially on the heavy loam type, erosion of clay " banks." Although the soils are of a heavy texture, fruits will often benefit from potash dressings and especially the Purple Pershore plum and the gooseberry Careless.

Haselor Series.

The growth of various tree fruits on this series is very uneven, and in most plantations there are patches of vigorous and poor trees. The results are definitely inferior to those on the related Evesham Series, the best plants resembling those on this latter series. Trees often show poor anchorage and chlorosis is fairly common in various fruits. Potash deficiency may occur on the gooseberry Careless.

Chadbury Series.

The behaviour of fruit trees and soft fruits on the soils of this series is generally similar to that of similar fruits on soils of the Evesham Series. On the best sites growth may be rather more vigorous than on the Evesham Series, but wet patches are more frequent and these may lead to definite failures. There is always a risk of waterlogging on these soils and drainage requires special attention. The wet conditions make the planting of raspberries and loganberries very speculative. Chlorosis is much less common than on the Evesham Series.

Charlton Bank Series.

The characteristic feature in this series is the seriously impeded drainage, and this is associated with drastic dying off of various classes of fruits. Although one apparently fairly successful apple plantation has been noted on the series, the soil must not be regarded as favourable to all fruits and should not be utilised for fruit growing.

Worcester Series.

This series is well suited to the growth of all classes of fruit, including cherries.

Plums grow rather more slowly than on the Evesham Series in their earlier years but eventually make large trees.

Chlorosis may occur where calcareous layers of rock are present, but these are infrequent.

Shallow Worcester Series.

These soils are unsuitable for all classes of fruits since growth remains dwarfed, which condition is associated with poorly weathered rock and unfavourable water conditions in the soils—alternating wetness and drought according to weather conditions.

Cropthorne Heath Series.

In this series there are three types, Light Sand, Heavy Sand and Light Loam, and all three types are unfavourable for fruit growing. Perhaps the most successful crop is strawberries.

Trees and bushes remain dwarfed in growth, the wood is brittle, and the plants age prematurely. No successful plantation of tree or bush fruit has been observed on the series.

The main problems appear to be potash deficiency, which is very acute and widespread, drought in summer, and waterlogging in areas associated with the occurrence of iron-pan.

Pershore Series.

This is one of the most widespread and important of the series. It contains four types, Light Sand, Heavy Sand, Light Loam and Heavy Loam, and each type shows definite characteristics in connection with fruit crops. In general, it may be said that the suitability of the types for various fruits increases in passing from the lightest to the heaviest type.

On the Light Sand Type, conditions are generally unfavourable for all classes of fruits, the results being often similar to those on the Cropthorne Heath soils, but can usually be improved by suitable management.

Plums are generally stunted, especially Pershore Yellow Egg, but varieties such as Belle de Louvain and Victoria make larger trees, although the wood shows the characteristic brittleness and early ageing, and fruit quality is generally inferior. Large plum trees, variety Victoria on the vigorous rootstock Myrobolan, have been grown at one centre under exceptionally favourable conditions of management.

Apples, pears, cherries and soft fruits can all be grown fairly successfully, although not so well as on the heavier types, provided high manuring is practised, especially with potash, and management is good in other ways.

Adequate potash manuring is the key to success on this type but attention must also be given to nitrogen supply and the careful selection of varieties and rootstocks, especially in the case of plums.

The type is probably best utilised for vegetable culture.

On the Light Loam the performance of all classes of fruits is rather variable. Under the most favourable conditions growth with all kinds is good (cherries excepted), but in many cases wet patches occur and these lead to bad failures of all fruits. Wetness is the major problem and the only other problem of outstanding importance is that of potash supply, though this is definitely of less moment than on the sand types.

Cherries have only been examined at one centre and the results appeared doubtful.

The Heavy Loam type is characterised by remarkably vigorous growth of all classes of fruits, some of the largest trees in the area occurring on this type, but occasional areas of defective drainage occur and these are associated with serious failures of all fruits.

Dunnington Heath Series.

This series comprises four types, Light Sand, Heavy Sand, Light Loam and Heavy Loam, as in the Pershore Series, and the soil characters resemble very closely those in the corresponding types of the latter series.

Although detailed investigations over a large area have not been carried out on the soils of the Dunnington Heath Series, the examinations made suggest that fruit trees and bushes on these soils will behave in a similar fashion to those on the corresponding Pershore types.

Dwarfing of the growth and the great need for potash on the lighter types, and vigour of growth and waterlogging effects on the heaviest type have been noted as characteristics on the Dunnington Heath soils.

Badsey Series.

There are three types in the series, Light Loam, Heavy Loam and Clay.

On the light and heavy loams the growth of various fruit plants appears to be similar. Plums and apples make only medium sized trees whilst soft fruits grow well, provided manuring and drainage receive adequate attention.

Vigour of growth on these types is closely correlated with the thickness of the surface sludge layer, deep sludge being associated with the stronger growth and thin sludge with weak growth, the poor condition in the latter instance being due to potash deficiency or drought, or to wetness in the gravel layer causing waterlogging.

On the clay type growth is stronger than on the loam types, and plums make vigorous growth and produce high quality fruits. The problems of poor growth which occur are similar to those on the loams and severe failures of both tree fruits and bush fruits from potassium deficiency may occur. The Badsey Clay differs markedly from the Evesham Clay in this respect.

Honeybourne and Shallow Honeybourne Series.

The characters of fruit trees and the problems which arise on the types in these series, Honeybourne Light and Heavy Loams and Shallow Honeybourne Heavy Loam and Clay, are similar to those for the corresponding types of the Badsey Series.

Under Badsey Series.

The growth characters of various fruits are similar to those on Badsey Clay, the trees and bushes tending to show somewhat low potash characters.

Longdon Hill Series.

The soils of this series produce very variable effects on the different classes of fruits and these appear to be due to the water conditions in the subsoil gravel layers. Serious waterlogging effects may occur, leading to total failure of tree and bush fruits, but where water conditions are favourable growth is free and the results good. Potash manuring may be required.

Hipton Hill Series.

This series, on the whole, is conducive to vigorous growth of tree fruits, plums in particular, and of various bush fruits, although lime-induced chlorosis and soil wetness may cause failures. Certain of the soils are also in unfavourable sites for fruit growing. Results with most fruits may be expected to be fairly similar to those on Evesham Clay.

CONCLUSIONS RELATIVE TO SOILS AND VEGETABLE CULTURE AND DISEASES.

Occurrence of Crops.

The cultivation of the various vegetable crops appears to be related to soil types rather than to series, soil texture being perhaps the critical factor. Different textures are sometimes preferred for a given crop, *e.g.* peas, for the production of early and late crops, in the former case, earliness being of importance and, in the latter, bulk of crop and soil moisture conditions requiring consideration. There is evidence that quality of certain crops, *e.g.* onions, is closely related to soil type.

The following preferences of various crops for particular soil types were shown.

Heavy Soils—Asparagus, Brussels Sprouts, Parsnips.
Light Soils—Runner Beans, Cabbage, Leeks.
Variable—Dwarf Beans, Cauliflowers, Marrows, Onions (Spring), Peas.

Diseases.

The incidence of diseases did not appear to be clearly related to the soil types. Thus where crops are evenly distributed over both heavy and light soils, diseases are generally also spread impartially, *e.g.* foot-rot in peas.

Club-root in Brassicae is rather more common on light than heavy soils, doubtless due to the higher lime content and better moisture-retaining properties of the latter.

REFERENCE.

(1) Wallace, T. "Fruit Soils Surveys." *Ann. Report Long Ashton Research Station*, p. 18, 1926.

A SURVEY OF THE SOILS OF THE LONG ASHTON RESEARCH STATION FARM.

By D. A. OSMOND.

The work recorded in this report was undertaken during the summer of 1934 with the object of classifying and mapping the soils of the Research Station Farm. Soil differences within experimental plots may cause considerable variations in tree growth and hence it was desirable to map the soils in some detail. The soils were mapped on a scale of 25 inches to 1 mile.*

At the completion of the work, it became evident that for the map to serve experimental requirements fully, the boundaries of the soil series should be accurate to within a few feet and in future some minor adjustments may be necessary on the map which has been prepared.

Physiography of the Farm.

The Research Station Farm is situated 4 miles to the west of Bristol, along the Bristol—Weston Road. The main portion of the holding is located in a shallow valley running approximately east and west, the remainder comprising the southerly slope of the ridge forming the south side of the valley. The hill on the north side of the valley rises to over 400 ft. O.D., whilst the southern ridge reaches 200 ft. O.D. This latter ridge slopes gently away southward into a second valley, the land rising again to the south towards Dundry Hill (600 ft. O.D.).

The floor of the main valley on the farm is approximately 140 ft. O.D., the eastern end falling gently to Ashton Brook, which forms the eastern boundary of the holding. After cutting its way through the southern ridge, the brook flows at right angles across the valley before turning eastwards to meet the River Avon nearer Bristol.

The Research Station Farm comprises 257 acres, of which approximately 100 acres are under fruit, the remainder being used as pasture land at the present time.

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* The Soil Map has been reduced to a scale of 10 inches to 1 mile (approx.) for reproduction in this Report.

Geology.

For such a small area the geology is comparatively complex, as no fewer than six "solid" geological formations are present. The succession of rocks from the older to newer formations occurs in the north and south direction at right angles to the main valleys and ridges, and is as follows :—

Carboniferous Limestone.
Millstone Grit.
Dolomitic Conglomerate.
Keuper Marl.
Rhaetic Beds.
Lower Lias Clays and Limestones.

The Carboniferous Limestone constitutes most of the northern hill, and in a small quarry (I)† the strata of two different beds may be seen dipping at a small angle to the south. The rock is a hard, bluish-grey, fossiliferous limestone with occasional red veins and patches which are frequently associated with cracks and fissures in the rock. It contains numerous very fine, perfectly formed needles of quartz together with a very small amount of "heavy" minerals.

The Millstone Grit formation occurs in small areas overlying the limestone, as a hard, purplish, fine-grained grit which outcrops to the east and west of the farm and probably directly underlies the soil in a small area of the holding. The rock is composed mainly of angular quartz grains with a small amount of "heavy" minerals.

Dolomitic Conglomerate is shown on the "solid" geological map as occupying a very small area in the north-east, and the beds were formerly worked for the iron-ore they contain.

The major part of the plantations overlies the Keuper Marl formation, which occupies the main valley between the two ridges. It is evident that the beds dip slightly to the south, and in addition, an anticline giving dips to the east and west also exists. This can be seen in the railway cutting which runs along the valley, where the exposed beds of Keuper and Millstone Grit formations are bent over a core of Carboniferous Limestone.

Several beds of different lithology exist in the Keuper rocks, but all contain numerous rounded quartz grains together with a very varied assortment of "heavy" minerals. Between the railway cutting and the crest of the southern ridge the following beds occur :—

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† Position indicated on map by this symbol.

(1) A purplish-red marl, which is impervious to water.

(2) A brown, fine grained sandstone, which is broken and crumbles readily.

(3) Red, unconsolidated, fine sandy material with patches of impervious red marl, as (1), and small areas of sandstone, as (2) ; this complex covers a relatively large area.

(4) A coarse grained, sandy rock, from which water issues after heavy rain ; this occupies a small area at the foot of the southern ridge near the west boundary of the farm.

(5) A bed of red marl similar to (1) above, but with narrow bands of tea-green marl near the crest of the ridge.

The outcrop of the Rhaetic formation occurs near the top of the northern slope of the southern ridge and is only a few yards wide and mostly covered by hedges. The cutting in the road to the west of the plantations—The Wild Country Lane—shows the transition beds as narrow strata of tea-green marl, red marl, blue-grey clays and a thin bed of Cotham Marble, the latter passing into the basal beds of the Lower Lias formation.

Beds of the Lower Lias formation are also exposed in a small quarry (II)† on the highest point of this southern ridge and appear as thin alternating layers of hard, bluish-grey limestone and dark grey clay. A thin bone bed has also been observed in this quarry. The rocks dip steeply to the south and the gently sloping land behind this ridge is formed from the Lower Lias clay with outcrops of Lower Lias limestone which appear as flat, light grey or cream-coloured slabs.

Superficial Deposits. There is no doubt that the whole of the northern hill area was previously covered by Keuper deposits which have been subsequently eroded. This is shown by the presence of large rounded quartz grains in the soil, its red colour and cubical fracture, and the absence of notable quantities of the fine quartz needles which would be present if the soil were derived entirely from the underlying Carboniferous Limestone rock. Pits and borings show the presence of pockets of undoubted Keuper Marl material at over 300 ft. O.D. and a thin layer of it can be seen in the quarry (I)† at 200 ft. O.D.

The lower slope of the hill is covered by a narrow strip of material which is probably mainly derived from Millstone Grit, Keuper Marl and Carboniferous Limestone, as it is red in colour and contains both angular and rounded quartz grains. The upper layers of this deposit are doubtless mainly colluvial.

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† See footnote p. 257.

Ashton Brook was probably much wider than at present and has cut its bed through the Keuper formation, exposing the bed rock in some places and at others covering it with river terraces of locally derived material.

The Keuper formation in the valley is covered by a deposit of variable thickness originating chiefly from the adjacent formations and is possibly mainly colluvial, even to-day heavy rainstorms causing much fine-sandy material to be moved down the slopes into the valley.

It is probable that the tea-green marl is also covered by a thin deposit of colluvial material derived from the beds of the Rhaetic and Lower Lias formations.

There is no evidence that any superficial deposit has been laid over the Lower Lias formation over the area of its outcrop on the farm.

Mapping Methods.

Mapping has been carried out by the methods recommended by the Soils Correlation Committee in the 1st Report, 1931, and the map made on a scale of 25 inches to 1 mile. Pits were dug at suitable points and descriptions of profiles made, each horizon observed being sampled. Fifteen pits were dug and fifty soil samples were collected and analysed.

After the main series had been established, the area was traversed and auger borings made as often as was necessary to determine the boundaries of the series. In some areas, borings were made every twenty paces. Stoniness, texture, topographic features and water conditions were denoted by appropriate symbols on the map.

Analytical data obtained include mechanical analyses, calcium carbonate, loss on ignition, organic carbon, exchangeable bases, and chemical analyses of the clay fractions.

The parent materials of the soils are classified in Table I according to the List of Parent Materials, Soil Surveyors Conference Paper No. 38, April 1936.

TABLE I.

	Parent Materials.	*Parent Material Group.*	*Geological Origin.*
I.	Red clay, calcareous.	9	Keuper Marl.
II.	Red clay, calcareous over sandstone, non-calcareous, grey.	9	Colluvial material, mainly Keuper Marl over Millstone Grit.
III.	Red clay, calcareous, over hard limestone, grey, with red staining.	9	Colluvial material, mainly Keuper Marl over Carboniferous Limestone.
IV.	Sand, non-calcareous, red.	13	Colluvial material, mainly of Keuper origin.
V.	Sandstone, non-calcareous red.	15	Sandstone bands in Keuper Marl.
VI.	Sandstone, non-calcareous red, micaceous.	15	Sandstone bands in Keuper Marl.
VII.	Clay and clay shales, cacareous, grey (with limestone bands).	7	Rhaetic and Lower Lias Limestones.
VIII.	Clay and clay shales, calcareous, grey.	7	Lower Lias Clay and Tea-green Marl.

The Soil Series.

As is to be expected in a survey of such a detailed character, minor differences in the soil profile have an added importance. which would not receive so much attention in a more extensive survey, and for this reason a comparatively large number of series have been differentiated. Whilst many of these are only of local importance, others are likely to be more widespread. The former series have therefore been numbered and the latter named—in some cases provisionally. In all, 15 series are described and a short description of the salient features of each is presented below. the series being grouped under their parent materials. The complete profile descriptions and analytical data are filed for reference at the Long Ashton Research Station.

I. Series Developed on Red Clay, Calcareous.

Worcester Series. Brownish-red, heavy sand or medium loam, generally non-calcareous to depth of 4 5 feet. Moderately well drained.

Worcester (*Shallow Phase*) *Series.* 5″—18″ brownish-red, non-calcareous, medium loam, overlying red, unweathered marl. The surface run-off is greater than penetration, hence droughty conditions prevail during the summer and waterlogging in winter. Drainage is impeded.

Series 8. 19″ of reddish-brown, calcareous, heavy loam with some yellow mottling below 14″, overlying non-calcareous, grey-brown, fine-sandy clay with much orange-yellow mottling. This rests on practically unweathered red marl at 24″. Drainage is impeded in this series.

Series 9. A brown to greyish-brown, medium loam with yellow mottling at 20″, resting on compact, moderately well-weathered marl. Black manganese dioxide concretions are large and plentiful throughout the profile which is non-calcareous. Drainage is somewhat impeded to the surface.

II. Series Developed on Red Clay, Calcareous, over Sandstone, Non-Calcareous, Grey.

Series 4. A thin grass mat over 9″—18″ of practically stoneless, brownish-red, slightly calcareous, heavy loam with a granular structure, resting on hard quartzose rock which does not weather rapidly. Drainage free.

III. Series Developed on Red Clay, Calcareous, over Hard Limestone, Grey, with Red Staining.

Series 1. A thick grass mat overlying 18″—24″ of stoneless, brown-red, heavy loam, possessing a well-marked granular structure. This rests directly on hard grey limestone, weathered fragments of which appear in the base of the profile. Drainage free.

Series 2. A shallow phase of series 1 and having a similar profile to that of series 4, except that limestone rock occurs at the base in place of quartzose rock. Drainage free.

Series 3. 24″ of brownish-red, non-calcareous, heavy loam with a granular structure, passing into a tough, compact, purplish-red clay of variable thickness. Drainage free.

IV. Series Developed on Sand, Non-Calcareous, Red.

Series 5. Reddish-brown, calcareous, heavy sand passing into a non-calcareous, medium loam with sandstone and limestone fragments below 20″. Freely drained.

Series 6. 20″ of pale, reddish-brown, non-calcareous, heavy sand, passing into purplish-red, fine sand or sandy silt with a few manganese dioxide concretions. The drainage of this series is slightly impeded.

V. Series Developed on Sandstone, Non-Calcareous, Red.

Series 10. 12″—14″ of slightly red-brown, fine sand, overlying purplish-red, coarse sand or sandstone. Drainage free.

VI. Series Developed on Sandstone, Non-Calcareous, Red, Micaceous.

Series 7. 10″—16″ of greyish-brown, non-calcareous, heavy sand with numerous black concretions of manganese dioxide, resting on a variable thickness of soft, fine-grained, micaceous sandstone, alternating with bands of purplish-red, silty clay to 7 feet. The drainage is somewhat impeded.

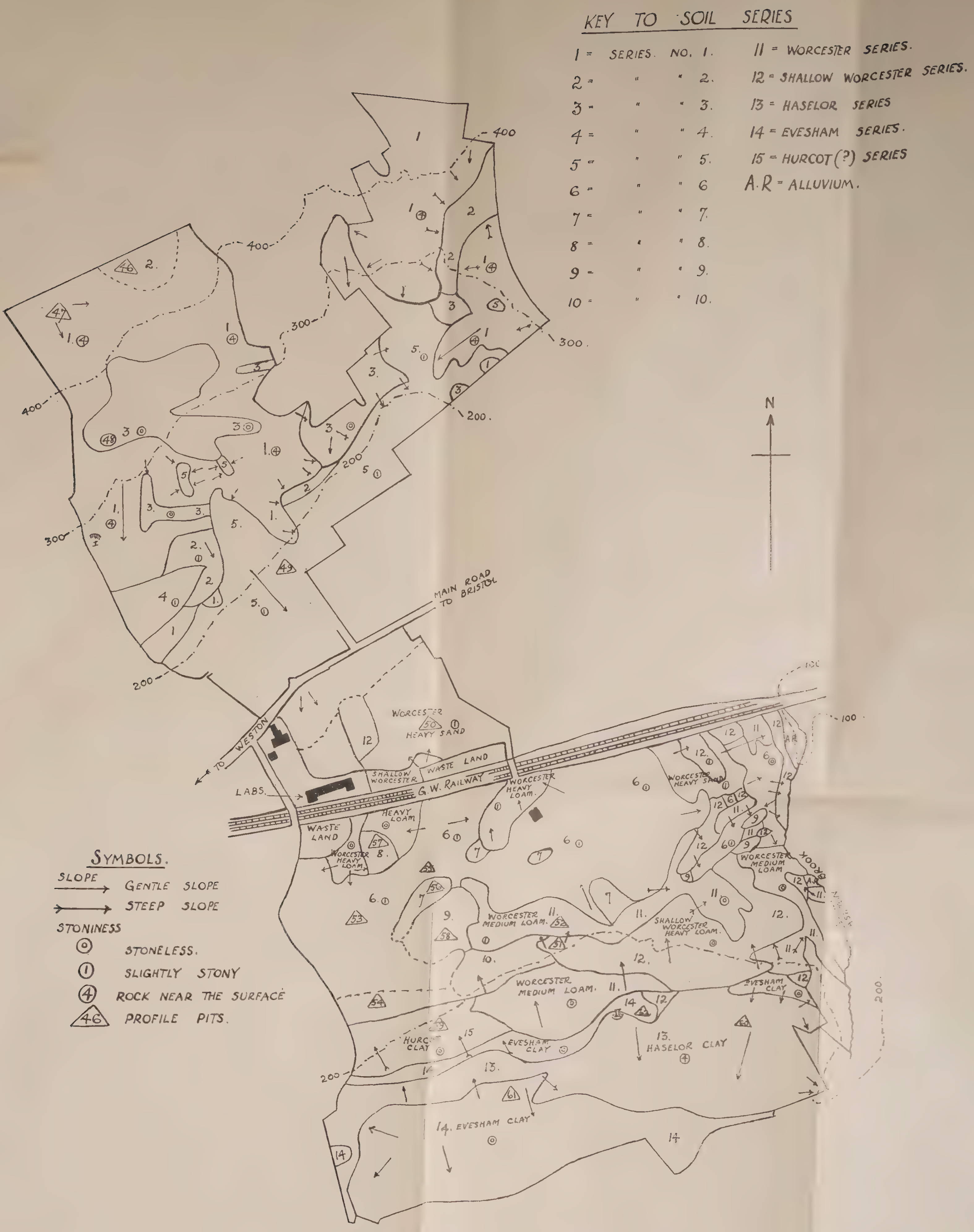
VII. Series Developed on Clay and Clay Shale, Calcareous, Grey (with Limestone Bands).

Haselor Series. Highly calcareous, blue-grey or brown clay, with rock occurring at or near the surface. Drainage somewhat impeded.

VIII. Series Developed on Clay and Clay Shale, Calcareous, Grey.

Evesham Series. Highly calcareous, brownish-grey clay, passing into a highly calcareous, blue-grey or dark grey shale at 2—3 feet. Drainage slightly impeded.

Hurcot (?) *Series.* 13″ of grey, non-calcareous clay, overlying greenish-grey clay with some yellow and brown mottling and small manganese dioxide concretions. This rests on dull, purplish-red, calcareous clay below 21″. Drainage somewhat impeded.



SOIL MAP OF THE LONG ASHTON RESEARCH STATION FARM ——

KEY TO SOIL SERIES

1 = SERIES. No. 1.
2 = " " 2.
3 = " " 3.
4 = " " 4.
5 = " " 5.
6 = " " 6
7 = " " 7.
8 = " " 8.
9 = " " 9.
10 = " " 10.
11 = WORCESTER SERIES.
12 = SHALLOW WORCESTER SERIES.
13 = HASELOR SERIES
14 = EVESHAM SERIES.
15 = HURCOT (?) SERIES
A.R = ALLUVIUM.

SYMBOLS.

SLOPE
→ GENTLE SLOPE
⇾ STEEP SLOPE

STONINESS
◎ STONELESS.
① SLIGHTLY STONY
④ ROCK NEAR THE SURFACE
△46 PROFILE PITS.

SCALE :—10 INCHES TO 1 MILE (Approx.

N
400
300
200
100
MAIN ROAD TO BRISTOL
TO WESTON
LABS.
G. W. RAILWAY
WASTE LAND
SHALLOW WORCESTER
WORCESTER HEAVY SAND
WORCESTER HEAVY LOAM
HEAVY LOAM
WORCESTER HEAVY LOAM
WORCESTER MEDIUM LOAM
SHALLOW WORCESTER HEAVY LOAM
EVESHAM CLAY
HASELOR CLAY
HURCOT CLAY
14. EVESHAM CLAY
BROOK
A.R
46
47
48
49
50
51
52
53
54
57
58
61

REPORT ON ADVISORY WORK, 1935-1936.

Although the number of enquiries received in the Department during the year, as given in the table of statistics, shows a slight decrease when compared with the preceding year (—59), in actual fact it will be seen from the report that the decrease is only due to an abnormal occurrence in one section, and that apart from this the volume of work continues to increase.

It was pointed out in the 1935 report that the large increase then recorded (+1753) was mainly due to the recent inauguration of the National Scheme of Accredited Milk Producers. It is natural to expect that after the initial flow of enquiries consequent on the introduction of the scheme the number from this source would fall and this has occurred with the result that enquiries under Dairy Bacteriology show a large decrease (— 740).

This year, for the first time, there have been included under Pomology 203 enquiries received by Mr. Locke, the Meteorological Officer at Long Ashton, who also carries out a considerable amount of advisory work on the identification of fruits and in connection with garden problems.

When these two factors which affect the comparative statistics are considered it will be seen that the number of enquiries during 1936 shows a substantial nett increase. Consideration of the reports of the Advisers in Agricultural Economics and Poultry Pathology, which contain matters not included in the statistics, also reflect continued expansion of the work in these subjects, numerical data relating to Poultry Pathology showing an increase of over 8,000 routine blood tests and over 600 examinations of pathological specimens.

The statistics presented in the table below refer to fourteen subjects, four of which are in connection with the work at the Berkeley Square Centre, whilst ten relate to work at the Long Ashton Institute.

At the Berkeley Square Centre, there is a nett decrease of 577 enquiries due to the special decrease of 740 shown under Dairy Bacteriology. The other subjects show the following changes :— Agriculture and Agricultural Chemistry (+ 178). Veterinary Science

(+ 20), Poultry Pathology (— 35). The enquiries given under Poultry Pathology refer only to Advisory Work carried out by the Poultry Pathologist on behalf of the Veterinary Investigation Officer under a special working arrangement. The main work of the Poultry Pathologist, which is not concerned with ordinary advisory enquiries, is referred to again below.

The above figures may be taken to indicate that the volume of enquiries at the Berkeley Square Centre continues to be very large. Whilst in Dairy Bacteriology there has been some re-orientation in work during the year, in Agriculture and Agricultural Chemistry steady progress has been made, and in the two Veterinary Sections, Veterinary Science and Poultry Pathology, the level of advisory enquiries has been maintained.

The Long Ashton subjects show a large increase (+ 518), the figures for the various subjects being as follows :—Cider (— 136), Cider Instruction (+ 63), Pomology (+ 199), Horticultural Chemistry (— 21), Economic Entomology (+ 31), Economic Mycology (+ 95), Insecticides and Fungicides (+ 32), Fruit Products (+ 346), Domestic Preservation (— 100), Willows (+ 41).

It will be seen that the main increases are recorded under Fruit Products, Pomology and Economic Mycology. The large increase under Fruit Products is the result of the commercial development of the research work carried out in this subject at Long Ashton ; in Pomology the increase is due to the inclusion of enquiries received by the Meterological Officer ; and in Economic Mycology, the weather conditions were responsible for increases in mycological problems, the wet conditions in June and July being favourable to the spread of fungoid diseases. In Cider Instruction it should be noted that Dorset was in the Scheme for a whole year in the 1935 – 1936 period, whilst Monmouth also participated for the period November 1935–September 1936. The further increase in Willows appears to be due to the continued interest shown in Cricket Bat Willow culture.

The only notable decreases were in Cider and Domestic Preservation. In the former case perhaps the main reason for the decrease was the continued attention of the Officer in charge of the Cider and Fruit Product Sections to the latter subject in a year so important in its development on a factory scale, whilst in Domestic Preservation the result is due to the policy of developing County Centres from which advice may now be obtained. Many of the County Officers responsible for the advisory work have attended courses given by the Long Ashton Instructress at Cirencester.

It is again gratifying to report a substantial increase in the routine testing work in the Poultry Pathological Section, as previously mentioned the increase in specimens for blood tests amounting to over 8,000 samples, whilst the number of pathological specimens received exceeded that of the previous year by over 600. It will be remembered that the Poultry Pathological Section was established by the University at the request of the neighbouring counties, and that it is not in receipt of grants but operates on a self-supporting basis.

It must again be emphasised that the present volume of advisory work calls for great effort from the officers responsible for the various sections, especially in certain cases at Long Ashton, where the officers are also responsible for considerable programmes of research work. At Long Ashton, the position has been even more acute than in previous years in the Cider and Fruit Products Section, where one officer is responsible for the two subjects, owing to the rapid development in the production of many Fruit Products, such as syrups and squashes, on a factory scale. In connection with the factory development in the production of fruit drinks, the season has been notable for two outstanding events in relation to advisory work. To demonstrate the operation of Long Ashton methods for the production of fresh fruit juices and squashes the services of the Products Officer were made available to Messrs. H. W. Carter & Co., Ltd., Bristol, to supervise production over the making season, the methods used being open to inspection by other manufacturers. A Products Tasting Day was also organised at Long Ashton, to which manufacturers and others were invited for the purpose of inspecting the range of products made from various fruits.

An important point in connection with the products work has been the development of fruit juices suitable for use in Milk Shakes, a development which it is hoped will help both the fruit grower and the dairy farmer.

In Pomology, advisory work in connection with visitors to the Institute, makes large calls on the time of the staff, none of whom are official advisers. Under Insecticides and Fungicides a large volume of verbal enquiries is also mentioned. Under Cider Instruction it should be noted that during the present year the three counties originally associated with the official scheme have all participated. The Instructor's report shows that in this branch of advisory work much help is being given to farmers both in orcharding and cider-making problems.

The advisory work in the present report is classified under fifteen heads, viz.: Agriculture and Agricultural Chemistry, Dairy Bacteriology, Agricultural Economics, Veterinary Science, Poultry Pathology, Cider, Cider Instruction, Fruit Products, Pomology, Horticultural Chemistry, Economic Entomology, Economic Mycology, Insecticides and Fungicides, Domestic Preservation of Fruit and Vegetable and Willow Growing.

Statistics relating to enquiries are available for all subjects excepting Agricultural Economics where the method of working does not lend itself to statistical tabulation of enquiries as a means of assessing the work of the section, since the personnel of the section concentrate on special problems of groups of farmers and on economic surveys of farming methods and special rural industries, and only consider to a small extent the special cases of individuals other than as they arise in group and survey studies. Actually during the year, 54 enquiries from individuals were dealt with.

Since the enquiries in Poultry Pathology differ in character from those in other subjects, involving mainly routine laboratory tests and the numbers being very large, the main work in this section is not included in the statistics, but only special enquiries are included which are dealt with by the Poultry Pathologist on behalf of the Veterinary Investigation Officer.

The numbers of enquiries submitted to the Department during the past six seasons are summarised in the following table :—

	Year ending September 30th.					
	1931	1932	1933	1934	1935	1936
Gloucester (including Bristol) ..	414	871	849	945	1602	1622
Hereford	159	169	310	337	360	497
Somerset	553	578	810	997	1119	1138
Wiltshire	265	343	481	476	1365	848
Worcester	323	399	455	496	528	509
Other Areas	919	960	1217	1562	1571	1872
	2633	3320	4122	4813	6545	6486

The figures are shown separately in the table for the five Counties which comprise the Bristol Advisory Province and for other Areas. In this latter category are included enquiries from Devon and Monmouth, both of which contribute annual grants to the Long Ashton Institute. These counties do not rank officially as part of the Bristol Province, though an arrangement is in force whereby Monmouth is recognised as part of the Province for advisory purposes relating to Horticulture, whilst close touch is maintained with the advisory personnel of both counties through the medium of the Horticultural Sub-Committee of the Provincial Advisory Council.

The data given do not include the numerous enquiries dealt with in personal interviews, during survey work, local investigations, shows, etc.

The following features referred to in the sectional reports below call for special mention :—

Agriculture and Agricultural Chemistry.

A further increase in the volume of advisory work is recorded. Apart from the normal routine enquiries concerning crop failures and livestock problems, the examination of by-products from various industries with a view to ascertaining the agricultural value of these materials is worthy of note.

Several farmers in the Bristol Province have installed one or other of the types of grass drier now on the market, and many samples of dried grass have been examined for these farmers in order to give them some idea as to the nutritive value of the products.

On the investigational side, the results of the Pig Husbandry investigation, which was conducted in conjunction with the Agricultural Organiser for Wiltshire, have been published in the Journal of the Bath and West and Southern Counties Society, Vol. X, Sixth Series, 1935–36, and the investigation on the effect of poultry on the chemical composition of herbage and soil has been completed, the results of which will appear in an early number of the Journal of the Ministry of Agriculture.

The " teart " problem in Somerset is claiming attention not only by the Advisory Chemists, but also the Veterinary Investigation Officer, and it is hoped to arrange for a comprehensive investigation to be conducted in collaboration with the Veterinary Research Officers of the Ministry of Agriculture.

The chemical examination of varieties of swedes grown on different soil types in Somerset has indicated an interesting correlation between soil types and the composition of swedes.

A very successful course of lectures on " Animal Nutrition " was given in the University to members of the corn and feeding stuffs trade in Bristol. This course, which consisted of six lectures, was attended regularly by 76 members.

Dairy Bacteriology.

The work in this section has been well maintained during the year. All pre-licence and post-licence samples submitted from Wiltshire and Gloucestershire in connection with the Accredited Scheme have been dealt with, but the examination of official samples for Hereford has been discontinued, as that County is now served by its own laboratory.

The operation of the Wiltshire County Accredited Roll—which has been re-named the Wiltshire Milk Testing and Advisory Scheme —and the annual clean milk competition in Worcestershire has again been a large feature of the advisory work.

Apart from the problems arising out of the above-mentioned educational schemes, other matters causing trouble in the production and handling of milk and milk products on the farm, and in the dairy, have been investigated. These problems included the incidence of mastitis in the dairy herd, the hygienic condition of milk churns returned from dairies to farms, ropy milk, slow cheese, and the examination of dairy water supplies.

A considerable volume of work has been accomplished on the revised Methylene Blue Reductase Test and this investigation is being continued on an expanded scale.

Agricultural Economics.

Although the number of farm visits paid by the Adviser is slightly less than in previous years, the volume of work has increased to a very large extent. Fortunately, the farmers who are keeping records under the various schemes which the Advisory Economist has in operation, now submit their records regularly, and on account of this fewer visits to farms have been necessitated.

The investigation into milk costs, which is being carried out on behalf of the Milk Marketing Board, is a salient feature of the Adviser's activities, and the new farm management survey scheme which is about to commence will play an important part in the work of the Adviser.

It is interesting to note that the enterprise studies into pig and poultry farming have given rise to certain research problems, and these have led to close co-operation between the Adviser, the Veterinary Officer and the Poultry Pathologist.

In spite of the immense amount of work executed by the Adviser during the year under review, he has found time to give a number of Extra-Mural lectures and to issue a large number of bulletins and reports.

Veterinary Science.

A further increase in the number of requests for advice on the many problems connected with the diseases of the domesticated animals is recorded.

Pathological specimens representing all classes of livestock, particularly sheep and pigs, have been received at the laboratory for examination, and in the majority of these cases one of the more common diseases has been found responsible. Considerable time, however, has been devoted to investigations into outbreaks of more obscure conditions, *e.g.* diseases associated with lambing.

The most noteworthy feature concerning diseases was the widespread nature of Pregnancy Toxaemia of ewes in early spring. The incidence of navel-ill was also high in spite of, in many cases, careful attention to hygiene at lambing time.

Poultry Pathology.

The progress made by the Poultry Laboratory has been well maintained, the number of blood samples and pathological specimens again showing a substantial increase.

The total number of blood samples examined reached the new figure of 98,000 and pathological specimens 1,570.

In addition, 114 requests for advice not accompanied by specimens were received, and in the assistance of the Veterinary Investigation Officer in dealing with poultry diseases 75 visits were made to farms in the Province.

Economic Entomology.

Enquiries as regards fruit pests were of more normal occurrence than in 1935, but the abnormally wet and sunless period of June and July led to a very marked decrease in many insects, including a number of species affecting a wide range of crops. Aphides were particularly affected.

A spray programme service dealing with the control of a number of the major fruit pests was put into operation with the aid of the provincial horticultural authorities. The service aimed at providing fruit growers with the correct dates and programmes for spraying.

A climatic check on the Codlin Moth rendered the infestations, which were serious in the previous season, of little importance in most localities. Experimental work showed that a high control of Plum Sawfly can be obtained by carefully timed applications of suitable washes. This pest is still on the increase and accounted for very serious losses of coloured plums. Red spider infestations were serious despite wet weather, and it is evident that special spraying will be necessary to control this pest. Woolly aphis attacks were appreciable.

Diseased conditions due to eelworm infestations continued to cause serious losses. The Frit Fly caused widespread damage to spring-sown oats. The cause of the so-called " Stigmonose " of tomatoes, attributed to insect attacks, was proved to be a type of " Water Scald." A distinct type of Parsnip Canker due to *Anguillulina dipsaci* was investigated. Further field trials with nitrogenous fertilisers in connection with pea and potato sickness due to *Heterodera schachtii* produced further interesting results indicating a relationship between " sickness " and nitrogen metabolism of affected plants. The hope that calcium cyanamide might prove a control of wireworm attack was not upheld.

Economic Mycology.

In Economic Mycology the enquiries received showed an increase of about 100 over the previous year.

Mr. P. W. Brian resigned his post of assistant in vegetable disease investigations in January, and was succeeded by Mr. C. J. Hickman, a post graduate student in Mycology at Birmingham University. Mr. D. L. G. Davies continued his post-graduate work on *Fusarium* diseases.

Further work was done on the fungi associated with fruit spotting and their relation to twig cankers, those chiefly studied being *Alternaria* spp., *Gleosporium album*, *Diaporthe perniciosa* and *Fusarium* spp.

Considerable progress was made in vegetable disease investigations. An important disease of peas, due to *Pythium ultimum*, was discovered in the Bromham area of Wiltshire. Excellent results have been secured, in collaboration with Dr. J. G. Horsfall, in the protection of pea seedlings from pre-emergence damping-off by chemical seed treatments. Observations have been made on the response of English varieties of beans to anthracnose, and it is hoped to amplify this work next year. The importance of mosaic disease on canning beans in this country has been pointed out. A classification of cabbage lettuces has been published by P. W. Brian, and an endeavour is being made to correlate the response of varieties to diseases with their place in these groupings.

Investigations on flower diseases included work on a new disease of chrysanthemum flowers caused by an unusual Phycomycete, and on lily root rots. Four different strains of *Cylindrocarpon radicicola* were shown to be incapable of causing root rots.

Willow Growing.

The improvement in the basket willow trade, which was noted in last year's report, has been maintained, and higher prices are now being realised for the growing crop and for prepared rods. The enquiries on cultivation problems show that an increase in acreage under basket willows may be expected.

Bat willow culture continues to extend, particularly in the western counties. The work which has been done at Long Ashton, which has had as its object the production of bat willow sets of better quality, is showing results in the better sets now demanded by planters and supplied by growers.

A new outlet for bat willow timber too poor in quality for bat making has been found by Messrs. Foreman, Chelmsford, who are using it for making crates and baskets.

The salient features of the work of each section during the year are summarised below :—

AGRICULTURE AND AGRICULTURAL CHEMISTRY.

The steady increase in the volume of advisory work reported previously has been maintained during the year under review, and again appreciation must be recorded of the co-operation and whole-hearted support of the County Agricultural Organisers in the Province and the members of the Staff of the Department of Agriculture and Horticulture of the University.

As in former years, specimens of weeds, herbage plants and rocks have been received for the purpose of identification and report as to commercial value, poisonous properties, etc., and the valuable assistance rendered by the Departments of Botany and Geology in the University in connection with this work is gratefully acknowledged.

During the year ended 30th September, 1936, 822 requests for advice were received which is an increase of 178 over the previous year.

During the year 315 visits were paid by the Adviser and his Assistants.

The number of samples received in the laboratory totalled 821, of which 362 were advisory and 459 investigational.

A few notes on some of the samples are appended.

Advisory.

Soils.

Most of the soils received were concerned with the problem of manurial requirements in connection with crop growth.

Fertilisers and Limestones.

The fertilisers examined were generally those which did not come within the jurisdiction of the Fertilisers and Feeding Stuffs Act. In the majority of cases they consisted of by-products such as kiln dust, tanyard sludge and the like, and they were received for determinations of their manurial value.

The limestones were mainly local products and in a few cases were received from local firms who required an opinion as to their suitability for agricultural purposes, either for application to the land or incorporation in rations.

Feeding Stuffs.

The large number of feeding stuffs received can be traced to the continued occurrence of digestive troubles amongst farm stock. The analyses conducted, however, did not in most cases support the contention that the foods alone were to blame.

Various by-products from manufacturing processes were submitted for opinion as to their suitability for incorporation in compound feeding stuffs. Amongst these must be mentioned Carite nuts, Illipe nuts and cocoa shell, and other by-products from the cocoa and chocolate industry. With regard to the cocoa shell and cocoa by-products, the analyses gave figures which could be interpreted to mean that they were valuable feeding materials, but a number of *in vitro* determinations of the digestible protein revealed a particularly low degree of digestibility, and assuming this to be true also of the other constituents, then these materials would appear to be less valuable as foodstuffs than indicated by the "total" analyses.

Herbage.

Most of the samples in this category were of dried grass from farmers in the Province who have installed grass driers. Data concerning the nutritive value of dried grass from the various types of grass driers are being collected.

Roots.

The samples of root crops were received from the County Agricultural Experimental Centres.

Viscera.

Viscera were submitted from animals suspected of either metallic or alkaloidal poisoning.

Investigational.

(a) Grassland.

(1) *Nitrogen and Mineral Uptake of Herbage.*

The series of experiments commenced in 1934 for the purpose of investigating the uptake of nitrogen and mineral constituents by grasses and clovers were continued. Further samples of herbage have been collected and separated into species, and these are being examined chemically.

(2) *Poultry Grassland.*

The analyses of samples collected in 1935 have been completed, and an article entitled "Some Observations on the Effect of Poultry on the Chemical Composition of Herbage and Soil" has been accepted for publication in an early number of the Journal of the Ministry of Agriculture.

In co-operation with the County Poultry Instructor for Somerset, a demonstration of the value of lime on poultry grassland has been laid down at Cannington, Somerset.

(3) *Teart Pastures of Somerset.*

The laboratory examination of soil and herbage samples has been continued. The absence of selenium from these samples has been demonstrated, but arsenic has been found in the herbage in amounts up to 20 parts per million, while spectrographic examinations have revealed the presence of molybdenum in unusual amounts in both soil and herbage. The significance of the presence of these toxic elements in the herbage of teart pastures is being studied as time permits.

Plans for a comprehensive investigation into the teart problem have been discussed with the Veterinary Investigation Officer at this Centre and the Ministry's Veterinary Research Officers at Weybridge, and details of these plans are being formulated.

It is interesting to note that in the late autumn of this year severe scouring was observed amongst the dairy cattle on three teart farms in Somerset, and the Veterinary Investigation Officer is studying the condition.

General.

Agricultural Survey.

The soil and agricultural survey of the Bromham district of Wiltshire has now been completed, and the map is in the hands of the printers.

Broadcasting.

Thirty-five evening broadcast talks to farmers were given in the West of England programme. Other Advisory Officers attached to this Centre and research workers from Long Ashton Research Station, as well as farmers and growers, have participated in these talks.

Lectures.

The usual course of lectures in Agricultural Chemistry was given to the B.Sc. (Agric.) degree students in the University by the Assistant Adviser.

In the spring a course of lectures on "Animal Nutrition" was given in the University to members of the Corn and Feeding Stuffs Trade in Bristol. The course consisted of six lectures and was attended regularly by 76 members.

In addition, 20 lectures were given to outside bodies on a variety of subjects, five of these lectures being under the Extension Lecture Scheme of the Ministry.

DAIRY BACTERIOLOGY.

During the year, the number of samples of milk and milk products submitted for examination from all sources was 15,590. The requests for advice totalled 1,438, and 24 advisory visits were made.

Competitions.

In collaboration with the County Agricultural Organiser, a very successful clean milk competition, extending over a period of six months, has been conducted in Worcestershire. This year, the competition included a special class for farmers who had recently obtained a graded milk licence but who had not had previous competition experience. Of the 54 competitors who participated—a record number for the County—40 obtained Certificates of Merit.

A clean milk competition, organised by the Gloucestershire Milk Recording Society and which commenced during the preceding year with 20 entrants, concluded satisfactorily. Another competition on similar lines has recently commenced.

Wiltshire Milk Testing and Advisory Scheme.

This Scheme is really the original County Roll of Accredited Milk Producers—the new title being introduced to avoid confusion with the National Accredited Roll.

The membership now numbers 150, and all enquiries and investigations arising out of the scheme have received attention with the collaboration of the County Agricultural Organiser.

Accredited and Grade " A " T.T. Official Samples.

The examination of all official samples from Gloucestershire and Wiltshire continues at the Provincial Laboratory under the supervision of the Advisory Bacteriologist. Of the total number of accredited milk samples examined under the National Scheme since its commencement, some 24% failed to reach the prescribed bacteriological standard. Approximately 75% of these failures occurred during the summer months when the prevailing atmospheric temperature was relatively high.

Trade Samples.

Many dairies have made use of the Provincial Laboratory in order to keep a check upon the quality of their raw milk supplies and also upon the efficiency of their processing equipment. Advice on all such matters has been keenly sought.

(4) *Sampling of Meadow and Pasture Herbage.*

Co-operation with the Agricultural Education Association Analysis of Fodders Sub-Committee (of which Mr. W. R. Muir. of this Department, is Secretary) has been continued. The aftermath of one acre of meadow land was systematically sampled both by plucking by hand and by clipping with shears. and the samples obtained have been analysed in respect of dry matter and nitrogen.

(b) Arable Land.

(1) *Sugar Beet Factory Waste Lime Experiments.*

Experiments with this material which are being carried out jointly by the Harper Adams and Bristol Provinces were continued at the same centre as last year, the crop during the present year being mangolds.

(2) *Fertiliser Value of Dried Poultry Manure.*

The Department continued to co-operate in the Ministry's scheme of field experiments designed to provide an estimate of the fertiliser value of dried poultry manure, and during the year under review experiments were conducted at three centres in the Province. At one centre the crop was potatoes and at the other two, swedes.

(3) *Swede Varieties.*

Varieties of swedes grown on different types of soil in Somerset were analysed for dry matter content. The results suggested an interesting relation between soil type and the composition of swedes.

(c) Livestock.

The Bath and West Society's Pig Husbandry Investigation.

This investigation, which was conducted in the years 1934-1935 jointly by the Agricultural Organiser for Wiltshire and the Adviser has now been completed and the findings published in the Journal of the Society.

Local Health Samples.

While there has been a decrease in the number of samples submitted under this heading owing to the Sanitary Inspectors being engaged with official sampling under the Accredited Scheme. contact with the Local Councils has been maintained and more educational samples are anticipated in the near future.

Special Advisory Work and Investigations.

Enquiries arising out of the competitions, advisory schemes and the National Accredited Scheme have been numerous, hence, in dealing with these, investigation and laboratory work had to be cut down to an absolute minimum. All official graded milk samples showing poor or abnormal results under the routine tests have been passed on to the Advisory Bacteriologist for further examination.

By so doing, valuable information was supplied to the milk producer who could apply remedial measures on the farm without any delay.

Mastitis.

Pressure of work in other directions has necessitated a less expansive investigation of individual cow samples than was undertaken last year. Special attention, however, has been concentrated on herds where the disease was known to be widespread.

Milk Churn Survey.

A small survey of the bacteriological condition of empty milk churns returned from local dairies to farms has been conducted.

Slow Cheese.

Several cases of slow cheese have been investigated from a bacteriological aspect but, while the phenomenon appeared to be biological in nature, the results were not conclusive. Further work on this subject is intended when the opportunity occurs.

Low Pressure Steam Sterilisers.

The investigation of the efficiency of low pressure steam sterilising outfits under farm conditions, which was commenced during the preceding year with the collaboration of the Wiltshire Agricultural Organiser, has now been completed and a full report issued.

Methylene Blue Experiment.

An experiment devised to obtain information of the value of the revised Methylene Blue Reductase Test for the commercial grading of milk has been commenced in conjunction with the National Institute for Research in Dairying and other Advisory Centres.

AGRICULTURAL ECONOMICS.

(1) Enquiries and Advisory Work.

During the year under review 389 visits were made to farms, and 2,502 letters were sent out, apart from a number of circulars. The decrease in the number of farm visits when compared with the previous year is due to the fact that additional visits were necessary in that year on account of the inauguration of the milk costing scheme. After keeping records for the first year, farmers continued to send the necessary information into the University during the second year as a matter of course, and the visits by members of the economics staff were curtailed accordingly. The increase in the number of letters during the year under review is due to the fact that queries in connection with the milk costs scheme were able to be settled through the post because farmers were then more conversant with the points likely to arise.

The number of enquiries originating from farmers, which may be regarded as distinct from those raised in the normal course of the various investigations, remains close to the figure of the previous year, at 54. It will be understood, however, that a very considerable number of problems are dealt with verbally during the year, and of these no record is maintained.

(2) Intelligence.

The combination of financial accounts and enterprise studies keeps the Advisory Economist in touch with the main economics problems in the Province. A number of more or less detailed problems concerned with milk production are being analysed in connection with the investigation into milk costs, now being carried out on behalf of the Milk Marketing Board. There is no doubt that this particular line of research is of great value to the farmers in this Province, and has caused many of them to take a keener interest in methods of dairy herd management.

The enterprise studies into pig and poultry farming, while on a much smaller scale than that for milk production, have also thrown up certain research problems, and in some cases have led to co-operation with the veterinary officer and the poultry pathologist.

The results of the survey of the market garden area around Evesham (Worcs.), clearly indicated the need for much more economic investigation in that district, but owing to the urgency of the other problems this need has not yet been met.

Beef production, which in this Province is carried on chiefly in Hereford, raises several problems of major importance. Hitherto this area has not been adequately covered by the Economist, but it is hoped that this will be remedied with the additional resources made available under the new Farm Management Survey Scheme now commencing.

(3) Investigation Work.

The following summary is given :—

(a) Financial Accounts.

There are now 141 farms from which financial accounts are received. The usual classification is given below :—

Proportion of Permanent Grass.	*No. of Farms.*	*Type of Farm.*	*No.*
0— 30%	12	Fruit and Market Gardening ..	8
		Mixed	4
31— 70%	45	Milk	13
		Fruit and Market Gardening ..	32
71—100%	84	Milk	46
		Mixed	38
	141		141

Total Acreage, 63,187.

(b) Surveys.

The survey of small market gardeners around Evesham, to which reference was made in the report of the previous year, has been completed. The object was to obtain certain social and economic information relating to growers who occupied holdings of under 25 acres. The sample was chosen so as to represent, as far as possible, the conditions in the various soil areas. Upon analysis it was found that in relatively few cases did the holding consist of one compact piece of ground. Even the very smallest holdings often comprised 2 or more parcels of land, sometimes separated by a distance of 2 or 3 miles. It was evident that the " Evesham Custom " of land transference facilitated the interchange of parcels of land.

At the time the survey was carried out, the growers had experienced three consecutive bad seasons, with the result that the income of some of the small growers had diminished to such an extent that they were forced to hire themselves out to more fortunate or larger growers.

(c) Enterprise Studies.

The Inquiry into Management for Milk Production has now completed its second year, and the requisite tabulations have been made and forwarded to the Ministry of Agriculture and the University of Oxford for the Milk Marketing Board. As usual, two six-monthly statements were made for each farm, one for the winter and one for the summer period. One hundred and ten farms, carrying 4,154 cows, were included in the investigation.

The Study of the Economics of Poultry Farming is now in its 4th year, 17 farms are co-operating and reports have been issued to each farmer concerned.

Seven farms made losses ranging from £15 to £229, while the range of profits on the remaining 10 farms was from £9 to £348, according to the size. Calculated as a percentage on costs, the lowest rate of profit found on the third largest farm was one of £17 on costs of £1,312, equivalent to 1.3%, while the highest rate was that of £172 on costs of £439, equivalent to 39.2%. On the other hand, the largest rate of loss was on a small farm, where on costs of £93 the loss amounted to £25, equivalent to 26.9%. It would involve too much detail to give here the explanation of these large differences in returns, but obviously the greatest factor making for profits is a large egg-yield per bird coupled with freedom from disease.

Another factor which has a considerable influence on profits is the proportion of eggs produced during the period of high prices as compared with that produced during the low-price period.

A Study of the Economics of Pig Production was begun a year ago on 33 farms. Unfortunately, complete records are only available from 16 farms. This decrease in number is due almost entirely to the fact that farmers would not continue to keep records when they had serious losses through disease.

Those farms which continued in the scheme are all mixed farms with the exception of one specialised farm. The pigs are housed in all kinds of buildings from the new Danish intensive type to disused cottages and loose-boxes.

The number of farms is too small to permit of any general deductions, but it may be stated that eleven farms show a profit and six show losses. Some of the losses are accounted for by disease.

Care has been taken to obtain accurate records relating to gradings. There are three important factors which influence grading results, namely :—

(*a*) Selection of breeding stock.
(*b*) Control of feeding.
(*c*) Housing conditions.

Breeding results are available on most of the farms, but space does not permit of the details being given here. The bulk of the pigs are Large White crossed with Wessex Saddleback.

The housing conditions of the pigs have been examined on all the farms, and from a comparison of housing with grading results, it is quite definite that the best grades do not come from the farms with the best housing conditions. This means, of course, that pigs placed in a modern house will not grade well if the food is fed in an uncontrolled manner.

The investigation is being continued.

VETERINARY SCIENCE.

(1) Enquiries and Advisory Work.

During the year under review 432 requests for advice were received, 465 pathological specimens were examined, and 138 visits were paid to farmers in the Province.

Some of the diseases of animals which have been responsible for losses in the Province are as follows :—

Sheep.

Pregnancy Toxaemia was widespread among ewes in the early spring. Losses on most of the farms were not severe, although in one instance 15% of the ewes in the flock succumbed to the disease. Several outbreaks of abortion among ewes were investigated with negative bacteriological findings, though in some instances the losses appeared to be due to excessive root feeding.

Severe losses among lambs from Navel-ill, due to Streptococcus infection, occurred on many farms in spite of the usual precautions.

Cattle.

As in former years Contagious Abortion continues to be the main subject of enquiry and further blood testing of selected herds is being continued as an aid to control.

One outbreak of Coccidiosis encountered among ten calves in a small paddock, resulted in the death of two of the animals.

Pigs.

Most of the common conditions affecting the pig, namely, Anaemia, Ascaris infestation, Erysipelas, have been encountered during the year.

One outbreak of Lung Worm occurred among pigs running in an orchard causing great unthriftiness and death in a number of cases. The remainder made a fair recovery on their removal to a concrete floored pen.

(2) Investigational.

Enquiries concerning management, feeding, etc., in flocks where Pregnancy Toxaemia had occurred and the collection of blood samples, when obtainable, were conducted during the spring.

The collection of data in outbreaks of Enterotoxaemia is being continued.

POULTRY PATHOLOGY.

A further substantial increase in numbers both of blood samples and pathological specimens has been recorded ; the numbers of the former totalled 98,902 and of the latter 1,570.

In addition, 114 requests for advice not accompanied by specimens were received and dealt with, and in the assistance of the Veterinary Investigation Officer 75 visits were made to farms in the Province.

The bulk of specimens examined have revealed all the more common diseases to which poultry are heir. Bacillary White Diarrhoea, Coccidiosis, Tuberculosis, intestinal parasitism and disorder of the reproductive organs have been responsible for the majority of disease losses.

Parasitic tape worms, especially *Davainia sp.*, have been extremely prevalent.

Infectious Laryngo-tracheitis has been diagnosed and investigated on four occasions on different premises, as also has Fowl Typhoid. In dealing with this latter disease, the testing of the remaining birds and prompt removal of reactors, together with movement of healthy birds to clean land and houses, was successful in checking the disease. Vaccination was not advised or adopted in any instance. These measures were adopted in three instances. On the fourth farm, the number of infected birds was found to be 80% of the flock, and in view of such a heavy infection all the birds were slaughtered.

Other than these instances, parasitic and paralytic conditions have been the subject of the investigational and advisory work.

CIDER.

The number of enquiries received was 613, including 183 under the Cider Instruction Scheme, in which the counties of Dorset, Monmouth* and Worcester participated during the year. The total shows a decrease of 73 compared with the previous year, due mainly to the Cider Research Officer being very fully occupied with Fruit Products research. A large number of requests for advice, 252, came from areas outside the Bristol Province, including a number from abroad, Ireland, Jersey (Channel Islands), Kenya, New Zealand, Denmark, France and Mexico.

Many analyses of ciders and reports on samples were involved in connection with the enquiries and, in addition, several determinations of sulphur dioxide and bottling tests were made.

Whilst enquiries were mainly of a general nature, concerning cider-making processes and farm-orcharding, certain problems were of special interest during the year. These included disorders of ciders, which were prevalent, especially "sickness," ropiness, darkening and acetification ; relationship between pressure of CO_2 in carbonated cider and the volume absorbed ; precise chemical methods for determination of various constituents, natural or added, in cider ; removal of pectin from cider and effluents ; preparation of cider vinegar and cider brandy ; bulk champagnisation of cider ; relationship between residual nitrogen content and time of bottling cider ; the use of wine yeast cultures for fermentation of apple juice ; the choice of metals for cider equipment.

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* Monmouth for the period November-September inclusive.

In connection with the use of metals in cider-making, much detailed analytical work has been done. Many new alloys have been examined and advice on their suitability given.

In tests on the use of very pure aluminium (99.5 and 99% pure) considerable corrosion of the metal by the cider has resulted.

Cultures of wine yeasts of the three types seen in use in Germany by the party of cider makers during the 1935 tour were obtained and samples sent to several cider factories for trial. The results have been most promising.

The Cider Instructor paid 131 visits to farms, 50 in Dorset, 18 in Monmouth and 63 in Worcestershire, in connection with problems of cider-making and cider-orcharding.

In Dorset, special attention was again given to cider-making in North Dorset and considerable progress was made. In West Dorset farm cider makers had a favourable year, and there has been a keen demand for their products.

Farm-orcharding has received much attention and advice has been given concerning replanting and renovation.

The work in Monmouth which was suspended in March, 1933, was recommenced in a modified form in November, 1935. Under the new arrangement much work is done in conjunction with the County Horticultural Superintendent. The Cider Department at Usk Agricultural Institution, where the students may undergo a course in cider-making, is under the Instructor's supervision.

Much attention during the year was given to the improvement of farm orchards, spraying demonstrations being given and general advisory work done.

In Worcestershire, interest in cider-making and farm-orcharding has continued to be keen and sales of farm cider appeared to be satisfactory during the year.

In the Pershore and Evesham districts, attempts have been made to improve the quality of cider produced from the culls of market varieties by re-soaking and re-pressing the juice with bittersweet pomace.

The Instructor has given considerable attention to farm-orcharding in conjunction with the County Horticultural Instructor.

FRUIT PRODUCTS.

The year under review witnessed remarkable developments in the advisory work in Fruit Products, due to the fact that several firms began production of juices, syrups and squashes according to the methods recommended by the Station as the result of the recent research work of the Fruit Products Officer.

The number of enquiries reached the very high total of 648, an increase of 346 over the previous year. 522 of the requests for advice came from outside the Province, and included Cambridge (23), Devon (44), Hampshire (19), Hertfordshire (8), Suffolk (42), Sussex (12), Australia (8), India (6), Ireland (8), Scotland (8), Tasmania (5).

The investigations into the use of pure syrups with milk received much publicity, and 387 enquiries concerning this matter received attention. Other subjects of enquiry were fruit wines (42), squashes (27), unfermented apple juice (42), use of enzymes (19), and the utilisation of dried apple pomace (33). 89 enquiries were also received relating to general problems of fruit products and the outlines of their manufacture, etc.

109 visitors were also received at Long Ashton, and in many cases the interviews granted were long, whilst some visitors stayed for a day or two to examine special points in detail.

During the spring and summer of 1936, the Products Officer took over the technical control of the manufacturing processes for juices and syrups at the factory of Messrs. H. W. Carter & Co., Ltd., Bristol, under a special arrangement between that firm, the University and the Ministry of Agriculture. This was the first case of large scale production of beverages following the Long Ashton methods, and between June and August 200 tons of fresh fruit were processed and converted into syrups. The factory, during the whole of the making season, was open to inspection by manufacturers and others interested in the development of the fruit juice industry.

In addition to supervising production at Messrs. Carter's, the Products Officer also paid many visits to factories commencing production of juices, syrups, etc., and in many cases supervised the processes during the first day of working.

A novel function of an advisory nature was also held at Long Ashton during the summer, which consisted of a special " tasting " day for sampling the various Long Ashton fruit products made in previous seasons. Over 100 representatives of the following industries and organisations were present, in addition to the University Agricultural Committee and officers of the Ministry of Agriculture :—Cordial and syrup makers, mineral water manufacturers, chocolate makers, malted milk makers, general fruit products manufacturers, Milk Marketing Board and National Milk Publicity Council. The personnel of the gathering reflected the wide group of interests associated with fruit products manufacture.

POMOLOGY.

624 enquiries were received, of which 229 came from sources outside the Bristol Province. The total shows an increase of approximately 200, but this is due to the fact that in the present year enquiries dealt with by Mr. Locke, the Station Meteorological Officer, who deals specially with problems relating to the naming of fruits and with garden problems, were included.

Enquiries from abroad were received from Australia, Canada, New Zealand, South Africa, Belgium, France, Holland, Japan and U.S.A.

The subjects of enquiry were very varied, but many referred to strawberry problems and the establishment of new orchards, in the latter cases the question of the relative merits of the intensive and extensive systems of fruit culture being usually raised.

Forty nine visits were paid to commercial farms during the year, and it must be pointed out that many other requests for visits were received but had to be declined or postponed owing to the limited time available to the pomologists for such work.

Visitors to Long Ashton to see the pomological staff become more numerous each year and during the 1935-36 period 13 overseas visitors and 83 from various fruit districts in this country were received.

In addition, numerous organised parties were conducted around the Station experimental plots.

HORTICULTURAL CHEMISTRY.

108 enquiries, including 39 from outside the Province, were received. Overseas enquiries were received from Northern Ireland, Tanganika, Argentine, France, Lithuania and U.S.S.R.

A large proportion of the enquiries related to problems of fruit tree nutrition and fruit storage. Fruit storage problems are beginning to assume considerable importance and are leading to enquiries relative to the establishment of special stores, particularly gas stores, and to various physiological troubles which may develop in fruits during storage in such stores.

Considerable attention was also given to cases of failure of market garden and glasshouse crops. The majority of these were complicated with fungus and virus troubles, and in the initial stages they presented great difficulties in diagnosis. Usually it was shown that soil and manurial factors were of secondary importance.

Special Investigations in Progress.

1. *Experiments on the Control of Lime-induced Chlorosis in Apples, Pears and Plums—in Somerset and Worcestershire.* The main point under investigation is to determine the time of duration of favourable effects on chlorosis of ferric citrate injections and of grass cover.

2. *Manurial Experiments on Apples and Black Currants—in Gloucestershire and Herefordshire.* Results continue as outlined in previous reports.

3. *Manurial Experiments on Asparagus—in Worcestershire.* The crops at the two centres—Perdiswell and Sedgeberrow—were recorded in detail for the first time. Since this was the first year of cutting and the season was wet and very favourable for vegetative growth, no differences due to manurial treatments were evident.

4. *Survey of Soils on the Lower Lias Formation.* The Soil Series recognised in the Somerset area were examined by the Executive Committee of the Soil Survey Conference. Good progress was made in mapping the area.

The detailed report on the Evesham Survey was submitted to the Ministry of Agriculture and Fisheries.

ECONOMIC ENTOMOLOGY.

The number of enquiries received was 621. Personal visits by the Advisory Officer totalled 256.

The main subjects of enquiry related to the following :—Plum

Sawfly, Apple Sawfly, Winter Moth, Red Spider, Codling Moth, Woolly Aphid, Currant Clear Wing Moth, Shot Hole Borer, Strawberry Seed Beetle, Flea Beetles, Cabbage White Fly and various Eelworm diseases.

Spray Programme Service.

A spray programme service which was inaugurated in 1933 to deal with Apple Sawfly was extended in 1936 to include Plum Sawfly, Red Spider, Raspberry Beetle and Codling Moth. Details of washes and their dates of application were distributed to growers through the medium of county agricultural authorities, the local press, National Farmers' Union branches, growers' clubs and by post.

Investigations in Progress.

Winter Washes.

1. Investigations on the control of lichens on orchard trees showed that winter spraying with a high boiling tar oil was the most effective.

2. Field experiments demonstrated that lauryl rhodanate provided a high control of aphid.

Combined Summer Washes.

The experimental work on combined washes was continued. The use of oil-lime sulphur-nicotine combinations showed that such washes were highly effective for the control of Apple Sawfly and Red Spider.

Evaluation of Wetters and Spreaders.

A biological method for the evaluation of wetters and spreaders was perfected. Apple Sawfly was used as the test insect. Experiments showed that a white oil emulsion was superior to water soluble wetters when used in conjunction with a rotenone-containing substance.

Rotenone-containing Materials.

Investigations were continued on the chemical and biological evaluation of rotenone-containing materials. The work included experiments with the ground root and extracts of *Derris* and *Lonchocarpus spp.*

Laboratory Evaluation of Insecticides.

Investigations on the laboratory evaluation of the insecticidal properties of materials were continued. The methods enable critical data to be obtained quickly and save a considerable number of elaborate field investigations.

Plum Sawfly.

A high degree of control of Plum Sawfly was obtained by the application of rotenone-containing washes. A white oil emulsion was the most effective spreader for the washes.

Codling Moth.

Field experiments were carried out on the control of Codling Moth, but climatic conditions were unfavourable for a sufficiently severe attack, and it was impossible to obtain significant results from the data.

Woolly Aphid.

Field experiments showed that two applications after petal fall of a combined white oil emulsion and nicotine wash provided a good control of both Woolly Aphid and Red Spider.

Eelworms.

(*a*) *The Control of Heterodera schachtii.* Experiments were repeated with potatoes and several strains of peas on the effect of calcium cyanamide and good results were again obtained. Comparisons were also made between calcium cyanamide, sulphate of ammonia and sulphate of potash, and the two former proved similar in effect in increasing yields but did not reduce cyst numbers.

(*b*) *The Oat Eelworm.* Pot and plot experiments were carried out to ascertain whether this pest is transmitted by means of seed. The evidence obtained was negative.

(*c*) *A Parsnip " Canker " due to Anguillulina dipsaci.* Field trials showed that this canker was caused by the strain responsible for onion " bloat."

Flea Beetles.

The seed dressing previously used was again tested in further field trials, and although good results were obtained in some, others were not so satisfactory owing to slow seed germination on cold, wet land.

The Cause of so-called "Stigmonose" of Tomatoes.

The "halo-like" circular marks could not be traced to any insect pest, as had been suspected, but were readily proved experimentally in the greenhouses at Long Ashton to be due to a type of "water scald."

Hop Insects. Control of Lettuce Aphids. Control of Aphis and White Fly of Brassicae.

Investigations planned on these subjects were either in abeyance or produced few results because of very adverse weather conditions causing low pest incidence.

ECONOMIC MYCOLOGY.

490 enquiries were received, compared with 395 last year.

The excessive amount of advisory work during the period under review limited the time available for research and investigational work. The following report gives a brief summary of the more important investigations in hand during the period.

Fruit.

Apple Fruit Spots, Fruit Rots and Diebacks.

The scarcity of fruit during 1935 limited the scope of this enquiry. Further investigations were carried out on the following: *Diaporthe perniciosa* and *Alternaria* spp. in their relation to leaf and fruit spotting of apples; *Fusarium* spp. in relation to twig cankers; the prevalence of *Gleosporium* and other fruit rots and spots.

Strawberry Root Rots.

No typical root rot was produced by growing strawberry plants in outside plots heavily infested with *Cylindrocarpon radicicola.*

Vegetables.

A full account of investigations on vegetable diseases under "Progress Report on Vegetable Diseases—VIII" appears in this Report, p. 139.

The chief diseases under investigation were anthracnose and mosaic of dwarf beans, mosaic and *Botrytis* of lettuces, mint rust, and *Pythium* foot rot of peas. Trials on the control of pea and potato "sickness," associated with the eelworm *Heterodera schachtii*, are reported in a special article.

Ornamentals.

A Disease of Chrysanthemum Flowers.

An important disease of chrysanthemum flowers resembling that caused by *Botrytis cinerea* was found to be due to a Phycomycete with asymmetric conidia.

Root Rot of Delphiniums.

This was shown to be caused by the fungus *Thielaviopsis basicola*.

Lily Diseases.

Infection experiments were carried out with four different strains of *Cylindrocarpon radicicola* isolated from lilies, but none were found to be pathogenic.

Attempts to bring about flower splitting by treatment of the bulbs with cold storage temperatures were unsuccessful.

INSECTICIDES AND FUNGICIDES.

The enquiries received by letter during the year totalled 140, of which 99 were from areas outside the Bristol Province and included 6 from overseas.

In addition many visitors were received at Long Ashton, interviews being accorded on 47 occasions to growers and to 17 representatives of commercial firms, and in this way at least 300 verbal enquiries were answered.

The proportion of enquiries from commercial firms was lower than in the previous year and the range of subjects was more diverse.

42 requests related to winter washes and 22 concerned spray spreaders, whilst 18 dealt with problems of combined washes, a subject which is assuming greater importance with fruit growers.

In connection with the enquiries, 30 samples of spray materials were submitted for examination by growers and advisory officers and 8 by commercial firms.

As illustrating the nature of these samples, the following may be mentioned : 9 winter washes, 6 oils for use in combined washes, a proprietary product for use against chrysanthemum rust, and a proprietary sulphur dust.

DOMESTIC PRESERVATION OF FRUIT AND VEGETABLES.

60 enquiries were answered during the year, this being a substantial decrease as compared with the previous year. Only 8 of the enquiries were from counties in the Bristol Province, the remainder emanating from 20 other counties.

The continuous decrease during the past two or three years is the direct outcome of the training of county officers by the instructress, so that many problems can now be dealt with locally by these, and the instructress is thus enabled to devote more attention to research matters.

The subjects of enquiry were, as usual, very varied, and it is of interest that several referred to the preparation and uses of fruit syrups. A short pamphlet was prepared on the use of these with milk.

Other subjects about which information was supplied were: types of bottles and sources of supplies; bottling and canning of fruit and vegetables; bottling of tomatoes; spoilage of bottled vegetables; use of sulphur dioxide for preserving fruit; pickles, marmalades and jams; uses of quinces; edible seaweed; preserving of horse-radish and mint.

Lectures and Demonstrations.

These were held at the following centres: Witney, Cardiff, Stowmarket.

Courses of Instruction.

Three courses in Fruit and Vegetable Preservation were held at the Royal Agricultural College, Cirencester, between July 14th and September 4th, which 38 students attended.

General.

The Instructress acted as a judge at the following produce shows: the British Dairy Farmers' Show in London; County Federation of Women's Institutes Exhibitions at Devizes, Tavistock, Colyton, Bideford, Exeter, Stowmarket, Blackpool, Cinderford, Bristol, Cheltenham, Stroud and Southampton; National Federation Competitions at the Royal Show, Bristol.

Close co-operation was again maintained with the National Federation of Women's Institutes, and the Instructress served on the Agricultural Sub-Committee of the National Federation and on the Rural Domestic Economy Committee of the Gloucestershire Federation of Women's Institutes.

WILLOW GROWING.

316 enquiries were answered, and of these 159 were from counties outside the Bristol Province.

The chief subjects of enquiry related to land suitability, varieties, insect and fungus pests and cricket bat willow culture. Two enquiries were made by tea-growing estates in Kenya, seeking advice on cultural methods and varieties suitable for growing for the making of gathering baskets used in the tea plantations. Arrangements were made for supplies of sets of several varieties to be sent to the colony for trial.

194 enquiries were made on Cricket Bat Willow growing ; these included requests by nurserymen on methods of raising sets, land problems in connection with planting, the treatment of growing trees and the value of fully grown trees.

The young bat willow trees which have been planted in the western counties during the past four years (about 10,000) have greatly added to the advisory work in this area.

Bat willow trees, 14 years old, which were cut in Yorkshire during the year yielded some first-class timber.

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